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DESIGN AND FABRICATION OF A HIGH-PERFORMANCE BRAYTON-CYCLE COMPRESSOR RESEARCH PACKAGE

2 of 2

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS 3-2778

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A DIVISION OF THE GARRETT CORPORATION

NASA CR-54368

FINAL REPORT

DESIGN AND FABRICATION OF A HIGH-PERFORMANCE BRAYTON-CYCLE COMPRESSOR RESEARCH PACKAGE

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

May 1965

CONTRACT NAS 3-2778

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AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

NASA CONTRACTOR REPORT

DESIGN AND DEVELOPMENT OF A HIGH-PERFORMANCE BRAYTON-CYCLE COMPRESSOR RESEARCH PACKAGE

AiResearch Manufacturing Company of Arizona

ABSTRACT

In this development program, advanced aerodynamic design procedures were used to design a high-efficiency radial compressor for operation on monatomic gases. The compressor research package consists of a 6-inch-diameter compressor wheel and shaft mounted on ball bearings and the associated mounting hardware. Following development testing, the final configuration was defined, and when the unit was tested on argon, efficiencies in excess of 0.80 total-to-total were obtained. Additional testing is to be accomplished by the NASA.

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SUMMARY

The NASA-Lewis Research Center is presently engaged in an investigation of the turbomachinery components of Brayton-cycle space power systems using solar or nuclear energy as the heat source and an inert gas as the working fluid. Under Contract NAS3-2778, three pieces of hardware are to be designed and developed. The hardware will be used by the NASA for the Brayton-cycle investigation and includes the following:

Compressor and Turbine Research Packages - The two research packages each include a cold gas model of a high-performance radial wheel and a suitable set of running gear with oil-lubricated bearings. Both research packages are to be used to evaluate component aerodynamic performance.

Gas Generator - This unit combines the turbine and compressor of the two research packages into a single hot unit with the running gear, including gas-lubricated bearings. The gas generator will be used to evaluate the Brayton-cycle turbomachinery in a complete system ground test loop.

This report describes the selection of the system design point and the design, fabrication, inspection, and testing of the compressor research package. The compressor design points for the research package is:

Working fluid	Argon
Mass flow rate, $\overset{\circ}{m}$ - lbs per sec.	0.621

Compressor inlet temperature, T_1 - ^oR	520
Compressor inlet pressure, P_1 - psia	6.0
Compressor pressure ratio, r_c	2.30
Design operating corrected speed, $N/\sqrt{\theta}$-rpm	37,900

$$\theta = \frac{T_1}{518.7}$$

The research package consists of a 6-inch-diameter compressor wheel and shaft mounted on ball bearings and the associated mounting hardware.

Development testing of the compressor consisted of running the uncut development impeller with three diffusers--a nominal diffuser, a negative 3-degree diffuser, and a positive 3-degree diffuser. After mapping with the three diffusers, the impeller was cut back and run with the nominal and the positive 3-degree diffusers. After the final impeller configuration was determined, acceptance testing of the shipping units was accomplished. The first shipping unit was run for three speed lines and the second shipping unit was operated at design speed for 1.2 hours.

At the conclusion of the compressor research package development two conclusions are evident:

(a) A high-efficiency radial compressor can be designed to operate on inert gas.

(b) At the design point, the efficiency can be accurately predicted (predicted η = 0.798, test η = 0.80).

DESIGN AND DEVELOPMENT OF A HIGH-PERFORMANCE BRAYTON-CYCLE COMPRESSOR RESEARCH PACKAGE

1.0 INTRODUCTION

This report describes the design, fabrication, inspection, and testing of a Brayton-cycle compressor research package that will be used to evaluate the aerodynamic performance of Brayton-cycle compressors. The compressor was designed for high-efficiency, low-Reynolds-number operation with an inert gas used as the working fluid. With the recent development of Brayton-cycle space-power systems, high-efficiency, low-Reynolds-number type turbomachinery has only recently been required and, therefore, no prior work on turbomachinery of this type has been accomplished.

The compressor research package consists of a 6-inch-diameter radial compressor wheel and shaft mounted on ball bearings with the associated mounting hardware. Notable features of the compressor research package include the advanced aerodynamic design procedures and the utilization of extremely thin blade sections. The same design goals have been used in a 6-inch-diameter turbine research package developed for NASA under the same contract and a 3.2-inch-diameter compressor developed for the Air Force [Contract AF33(657)-11721].

With the development of the compressor research package, the feasibility to design high-efficiency radial compressors for operation on inert gas has been proven. Test results on the compressor research package when tested on argon indicated efficiencies in excess of 0.81 total-to-total.

2.0 SELECTION OF DESIGN CONDITIONS

Figure 1 shows a schematic of the NASA Brayton-cycle space power system. Contract NAS 3-2778 calls for the development of the gas generator package, a turbine research test package, and a compressor research test package, with the same turbomachinery used in the test packages as in the gas generator. As specified by the contract, the gas generator and research test packages have identical design conditions when corrected mass-flow rates are compared. Table 1 presents a summary of the design conditions as specified by the contract. In addition to the conditions listed in Table 1, the most important remaining system variables include:

(a) Recuperator effectiveness, E_R

(b) Pressure loss parameter, r_t/r_c

(c) Shaft speed, N

(d) Compressor specific speed, N_{S_c}

As the recuperator effectiveness is increased, the cycle thermal efficiency and mass-flow rate increase and the optimum compressor pressure is reduced. The low compressor pressure ratio, in turn, leads to higher compressor efficiency. Moreover, at low power levels, the increased mass-flow rate is beneficial to the turbomachinery as a result of the higher attendant Reynolds number in the turbine and compressor. Since increased recuperator effectiveness lowers both the radiator inlet temperature and

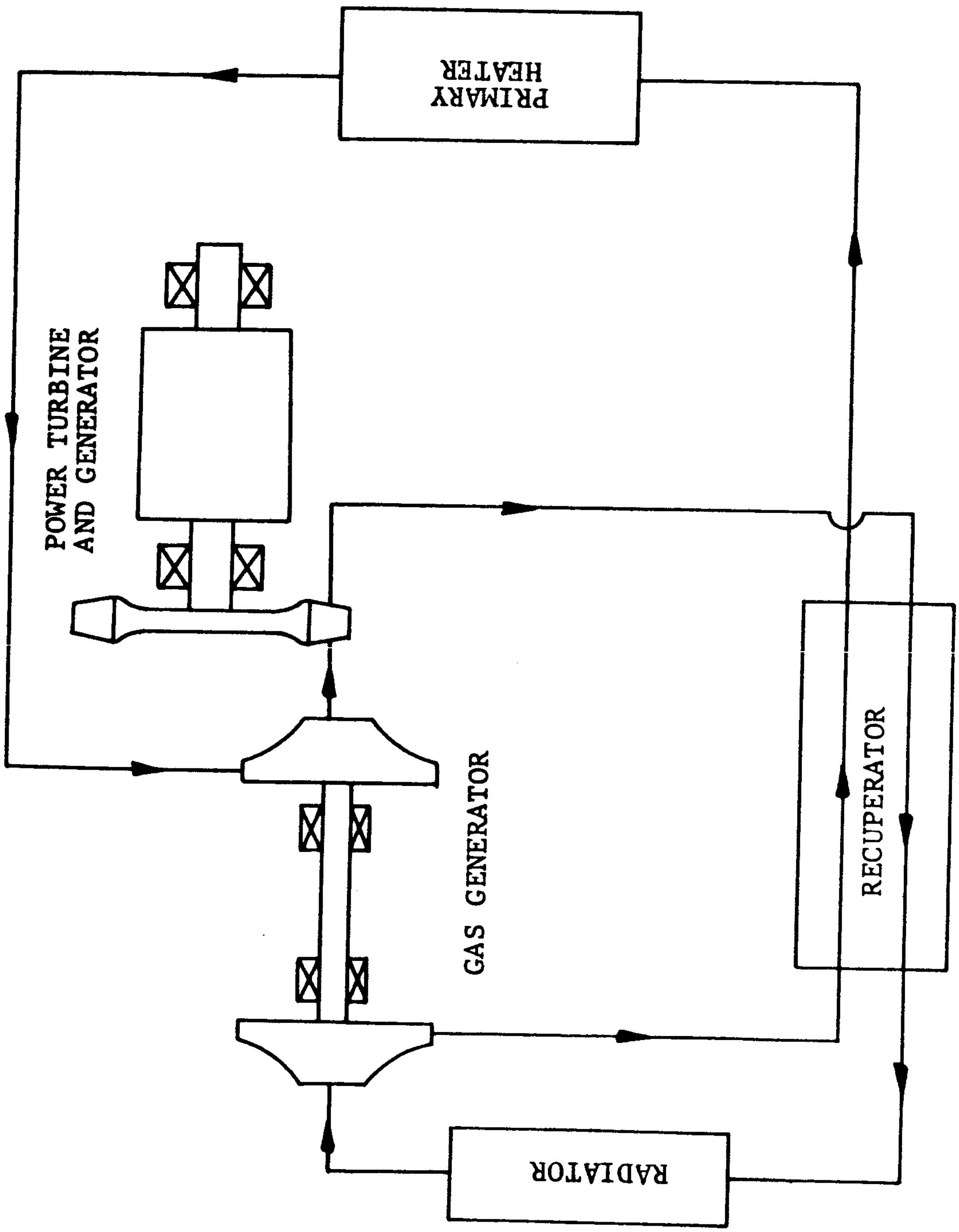

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FIGURE 1

NASA BRAYTON-CYCLE-POWER SYSTEM

TABLE 1

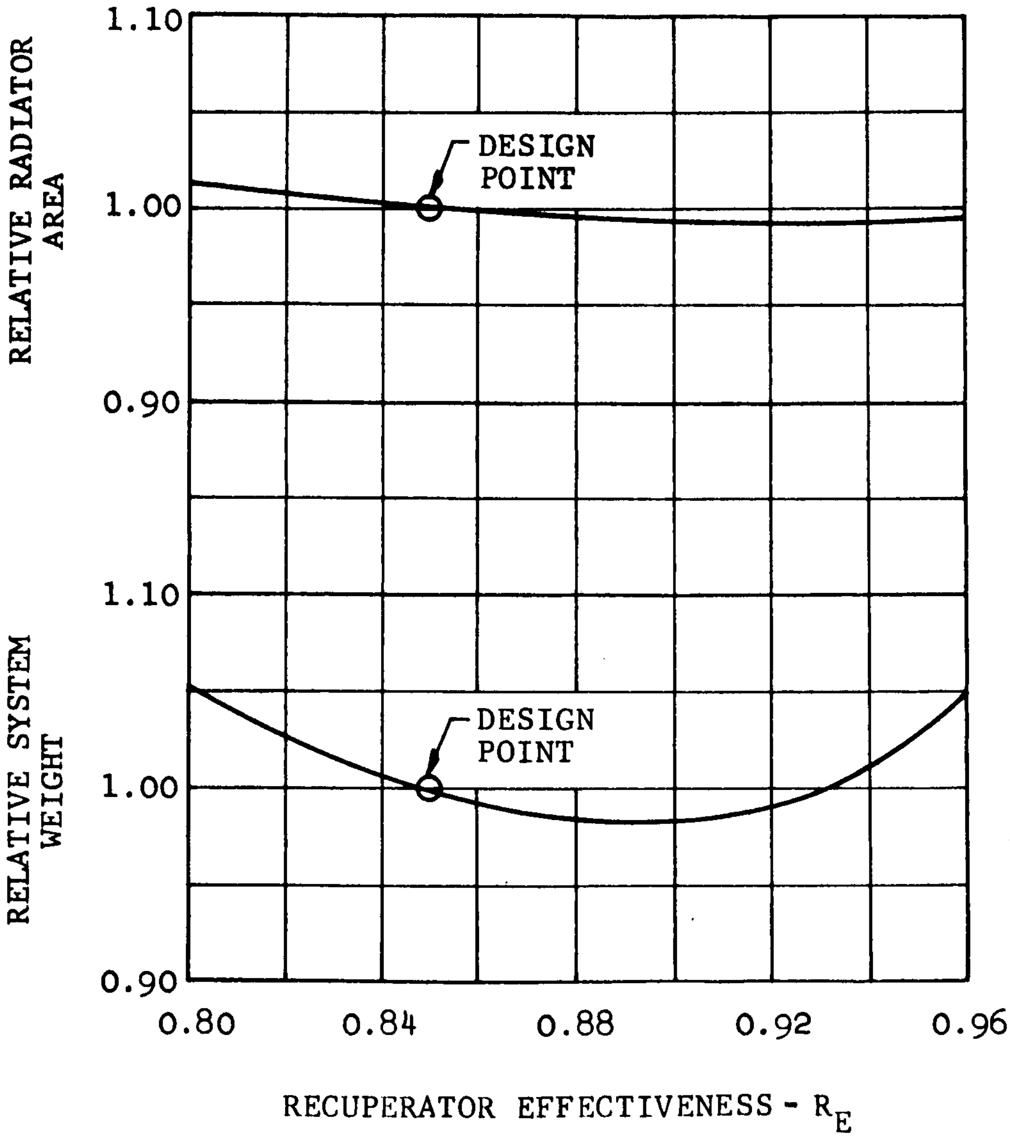
DESIGN PARAMETERS FIXED BY
CONTRACT NAS 3-2778

	Turbine Package	Compressor Package	Gas Generator
Working fluid	Argon	Argon	Argon
Mass flow rate, $\overset{o}{m}$ -lbs per sec.	1.184	0.621	0.611
Turbine inlet temperature, T_3, ^{o}R	520	-	1950
Turbine inlet pressure, P_3, psia	13.2	-	13.2
Turbine pressure ratio, r_{t_1}	1.56	-	1.56
Compressor inlet temperature, T_1, ^{o}R	-	520	536
Compressor inlet pressure, P_1, psia	-	6.0	6.0
Compressor pressure ratio, r_c	-	2.30	2.30
Corrected mass flow rate:			
$W\sqrt{\theta}/\delta$ turbine, lbs per sec.	1.3185	-	1.3185
$W\sqrt{\theta}/\delta$ compressor, lbs per sec.	-	1.5214	1.5217

the heat load, the radiator area is not strongly affected. Referring to Figure 2, the optimum recuperator effectiveness is established by a weight tradeoff between the recuperator and other components. Although a recuperator effectiveness of 0.9 appears to be optimum, a value of 0.85 has been chosen in view of the mass flow rate and compressor pressure ratio being specified.

The effect of the cycle pressure-loss parameter on system performance is shown in Figure 3. Although a value of 0.95 would be near optimum for the pressure-loss parameter, the value chosen was 0.90. This value allows increased flexibility, since the heat exchangers and manifolds would have to be designed for extremely low pressure drops if a pressure-loss parameter of 0.95 were utilized.

With the design point conditions listed in Table 1, a recuperator effectiveness of 0.85, and a pressure-loss parameter of 0.90, a design-point study was conducted to establish the gas generator thermodynamic and aerodynamic operating conditions. Figures 4 and 5 illustrate the variation of wheel diameters, component and cycle efficiencies, component specific speeds, and turbine pressure ratio over the range of shaft speeds with the turbine and compressor matched. (A list of the symbols used throughout this report can be found on page 10.) Wheel diameters of 6 inches occur for both the turbine and the compressor at a shaft rotational speed of 38,500 rpm with reasonable adiabatic efficiencies for the units. With this size wheels, manufacturing tolerances can be readily maintained to provide aerodynamic passages with surfaces that are hydraulically smooth.



VARIATION OF SYSTEM WEIGHT AND RADIATOR AREA
VERSUS RECUPERATOR EFFECTIVENESS

FIGURE 2

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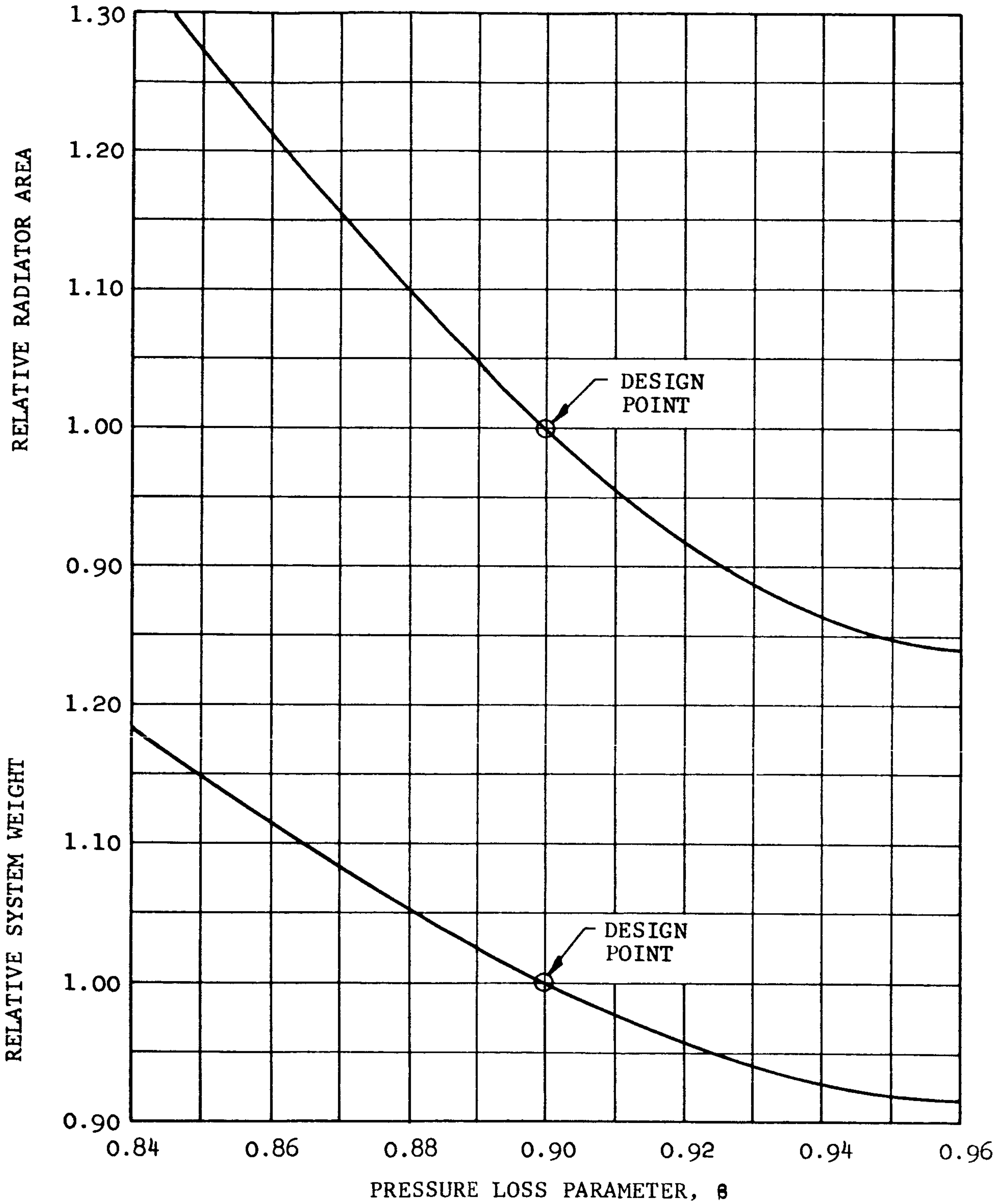
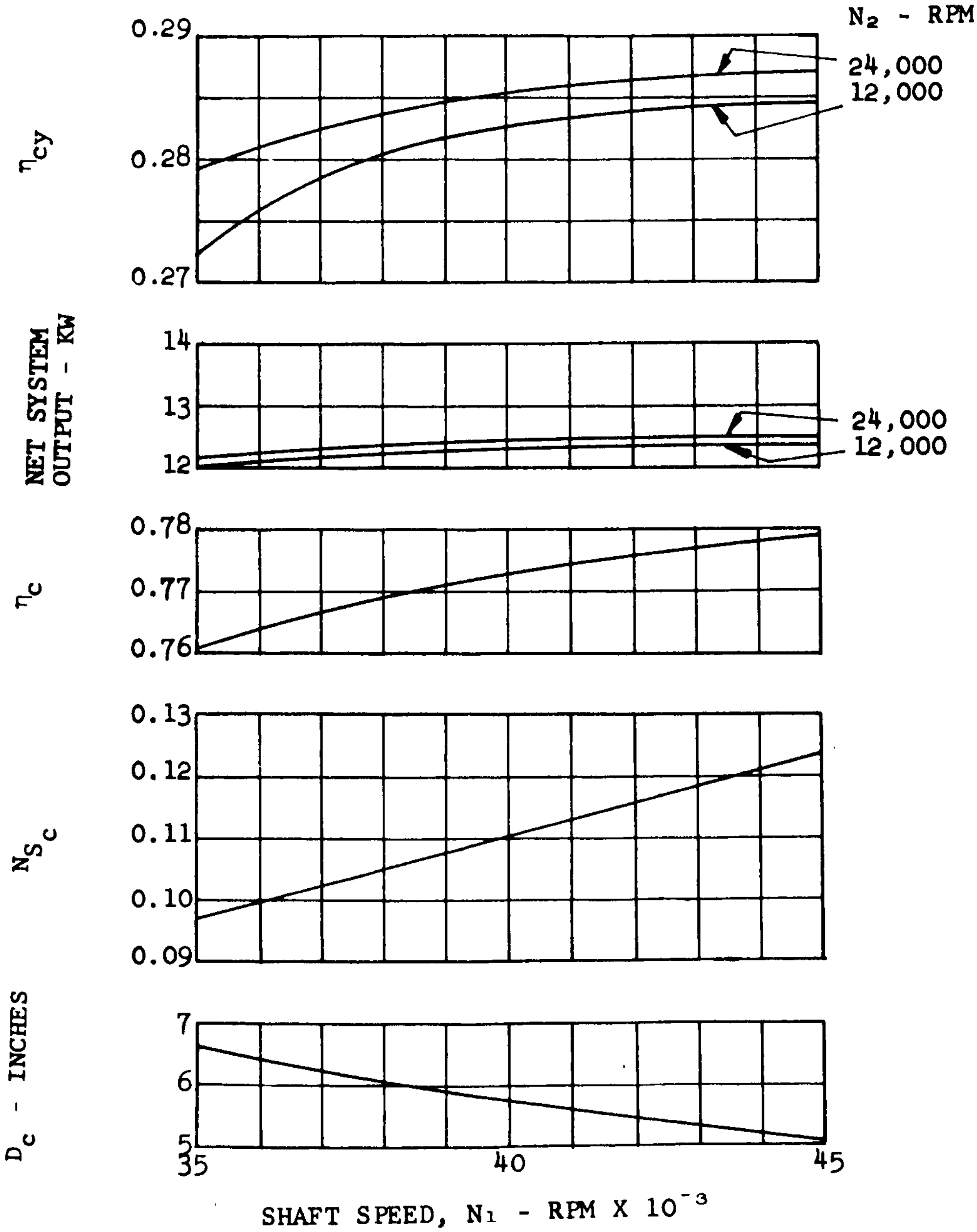


VARIATION OF SYSTEM WEIGHT AND RADIATOR AREA
VERSUS PRESSURE LOSS PARAMETER
FIGURE 3

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON

$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90

COMPRESSOR PRESSURE RATIO, r_c = 2.30
COMPRESSOR INLET PRESSURE, P_1^c = 6.0 PSIA
MASS FLOW RATE, $\dot{m}$ = 0.611 LBS PER SEC



COMPRESSOR DESIGN
NASA DESIGN POINT
FIGURE 4

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COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON

$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90

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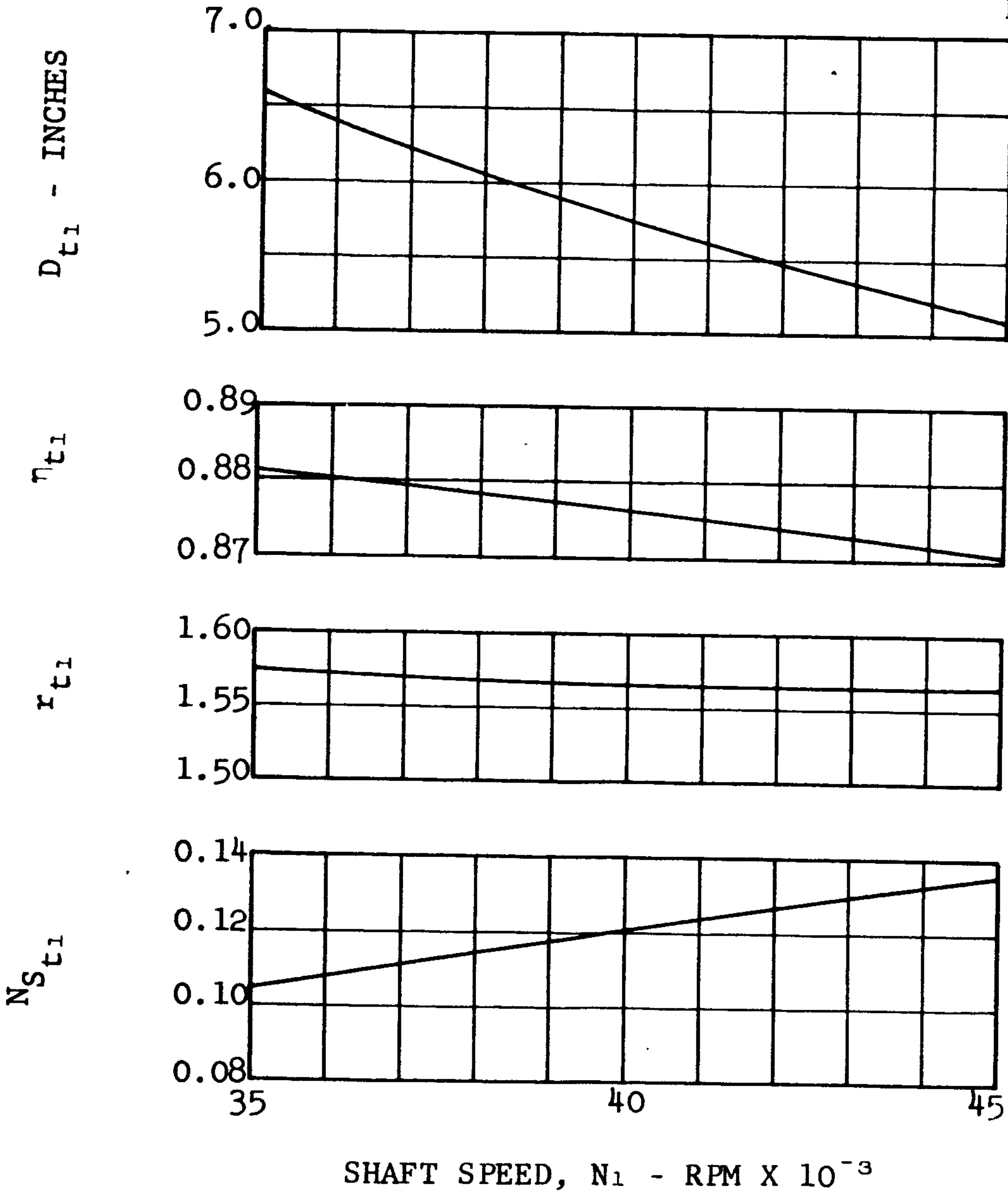


FIRST STAGE TURBINE
NASA DESIGN POINT
FIGURE 5

LIST OF SYMBOLS

g = conversion factor = 32.2 ft lb per lb sec.^{2}

$\overset{o}{m}$ = molal gas flow rate, lbs mol per sec.

r_c = compressor pressure ratio

r_{t_1} = gas-generator turbine pressure ratio

r_{t_2} = power-turbine pressure ratio

D_c = compressor-wheel diameter, inches

D_{t_1} = gas-generator turbine-wheel diameter, inches

E_R = recuperator effectiveness

M = molecular weight, lbs per lb mol

N_1 = gas-generator shaft speed, rpm

N_2 = power-turbine shaft speed, rpm

N_{S_c} = compressor shaft speed

$N_{S_{t_1}}$ = gas-generator turbine specific speed

$N_{S_{t_2}}$ = power-turbine specific speed

P_1 = compressor inlet pressure, lbs per sq ft

P_3 = gas-generator turbine inlet pressure, lbs per sq ft

R = universal gas constant = 1545 ft-lbs per lb-mol $^{\circ}R$

T_1 = compressure inlet temperature, $^{\circ}R$

T_3 = gas-generator turbine-inlet temperature, $^{\circ}R$

$$\beta = \frac{\text{turbine pressure ratio}}{\text{compressor pressure ratio}} = \frac{r_{t_1} \times r_{t_2}}{r_c}$$

LIST OF SYMBOLS (Contd.)

γ = ratio of gas specific heats = 1.667 for monatomic gases

θ = $(\gamma - 1)/\gamma$ = 0.4 for monatomic gases

η_{cy} = $\dfrac{\text{power-turbine shaft power output}}{\text{gas-cycle input rate}}$

η_c = compressor adiabatic efficiency

η_{t_1} = gas-generator turbine adiabatic efficiency

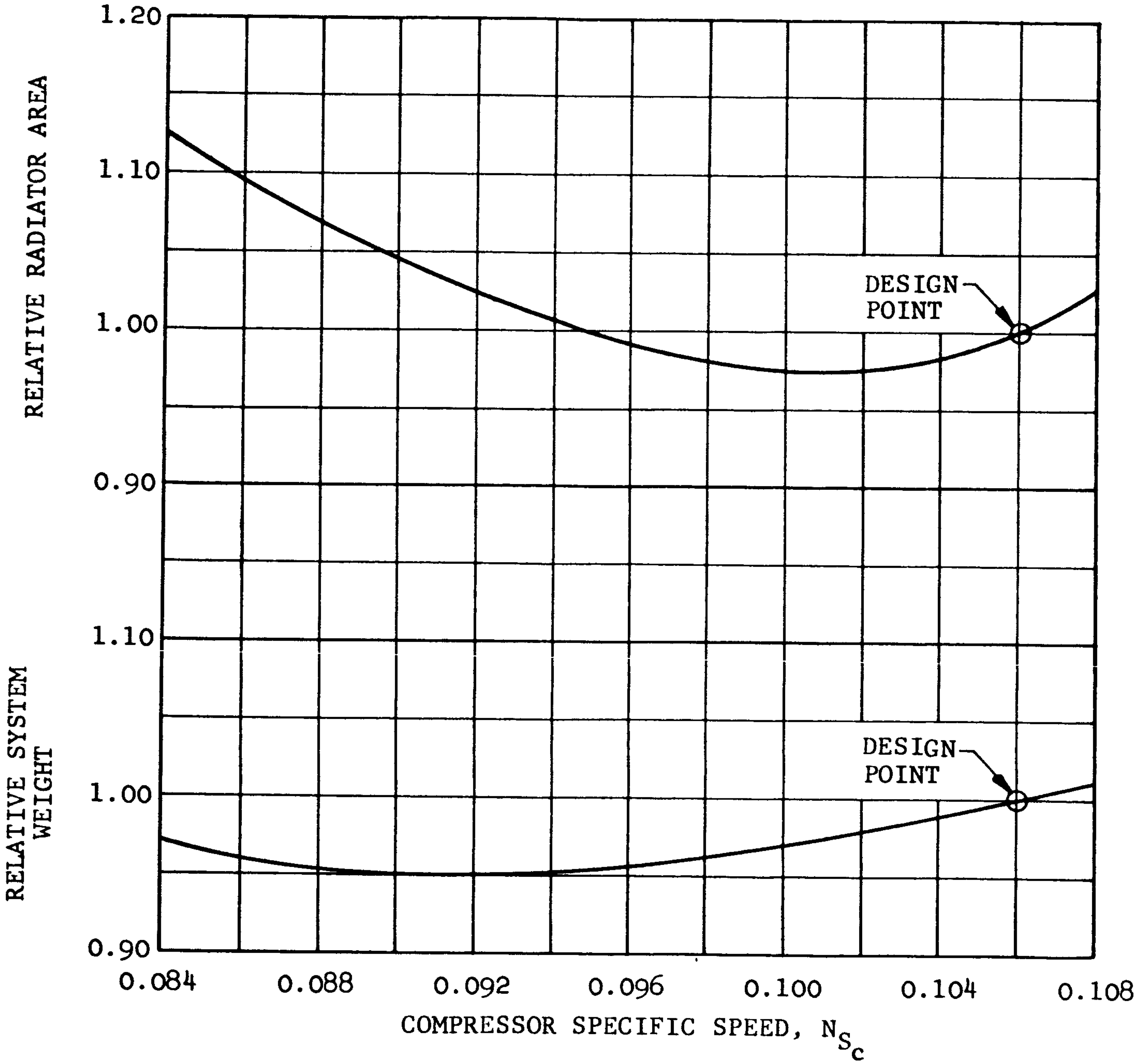
η_{t_2} = power-turbine adiabatic efficiency

A low compressor specific speed results at the shaft speed of 38,500 rpm, and the cycle efficiency is not seriously reduced from that which would be obtained at higher shaft speeds and smaller wheel diameters. The variation of system weight and radiator area versus compressor specific speed is shown in Figure 6. A compressor specific speed of 0.09 is near optimum based on the consideration of system weight; based on the consideration of both system weight and radiator area, the optimum specific speed is approximately 0.096. From the expression for compressor specific speed

$$N_{S_c} = \frac{N}{60}\left(\frac{1}{RT_1}\right)^{1/4}\left(\frac{\dot{m}}{P_1}\right)^{1/2}\left[\frac{(\gamma - 1)M}{\gamma g(r_c^{\theta} - 1)}\right]^{3/4}$$

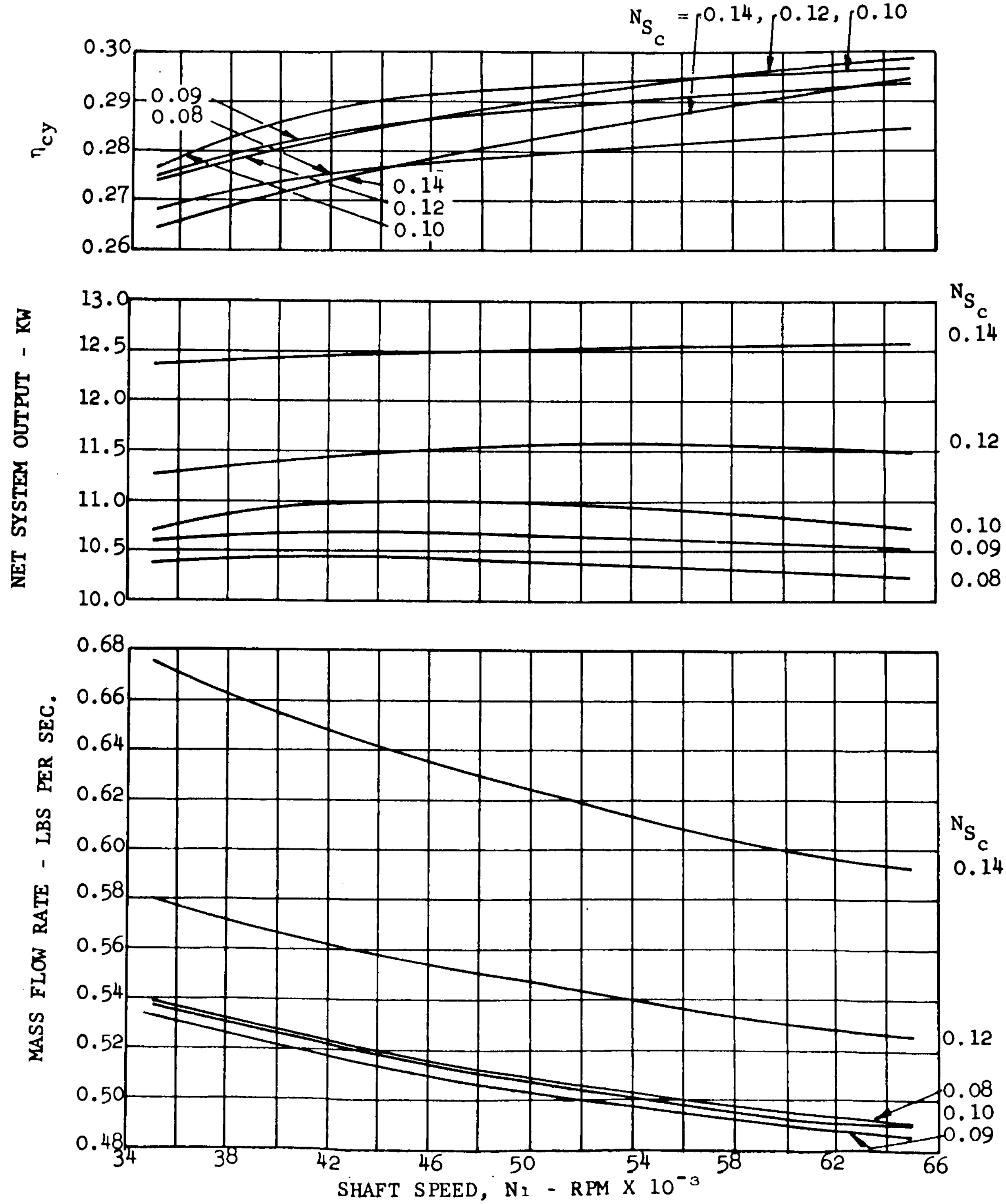
it can be seen that the compressor specific speed is a function only of shaft speed, since the remaining variables are fixed by the contract. Therefore, the shaft speed selected is nearly optimum for the specified conditions. A lower shaft speed would result in a more desirable compressor specific speed, but the wheel sizes would be unnecessarily large and the slow speed could result in bearing problems.

Additional computer runs were made with variable cycle pressure level, mass flow rate, and compressor pressure ratio (variable compressor specific speed) over a gas-generator speed range of 35,000 to 65,000 rpm with a free-turbine shaft speed of 24,000 rpm. These calculations were made to supply added insight into the design-point examination and are summarized in Figures 7 through 11.



VARIATION OF SYSTEM WEIGHT AND RADIATOR AREA VERSUS COMPRESSOR SPECIFIC SPEED
FIGURE 6

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPREATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90
FREE TURBINE ROTOR SPEED, N_2 = 24,000 RPM



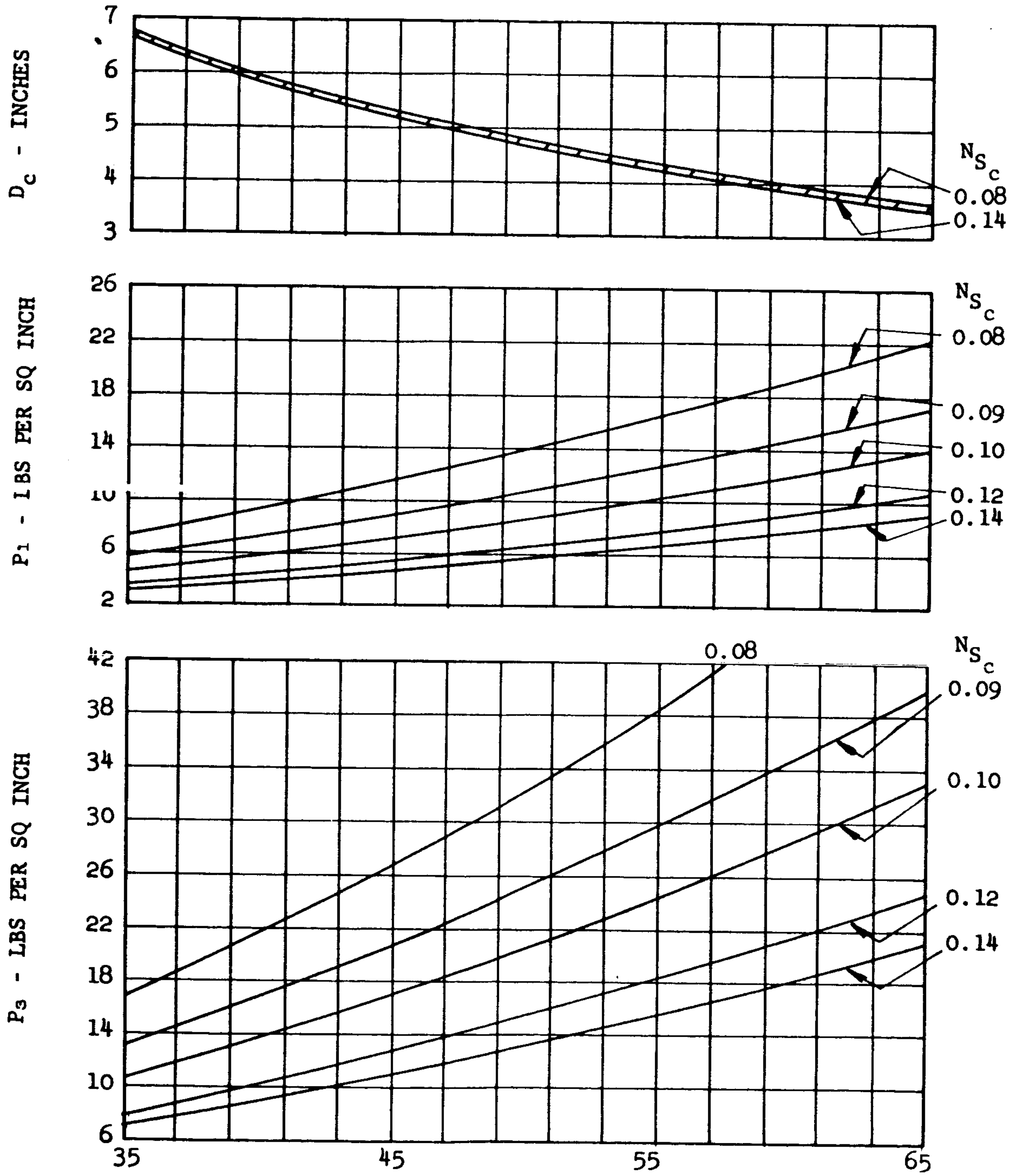
OPTIMIZED NASA SYSTEM

A31494-1

FIGURE 7

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON

$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90

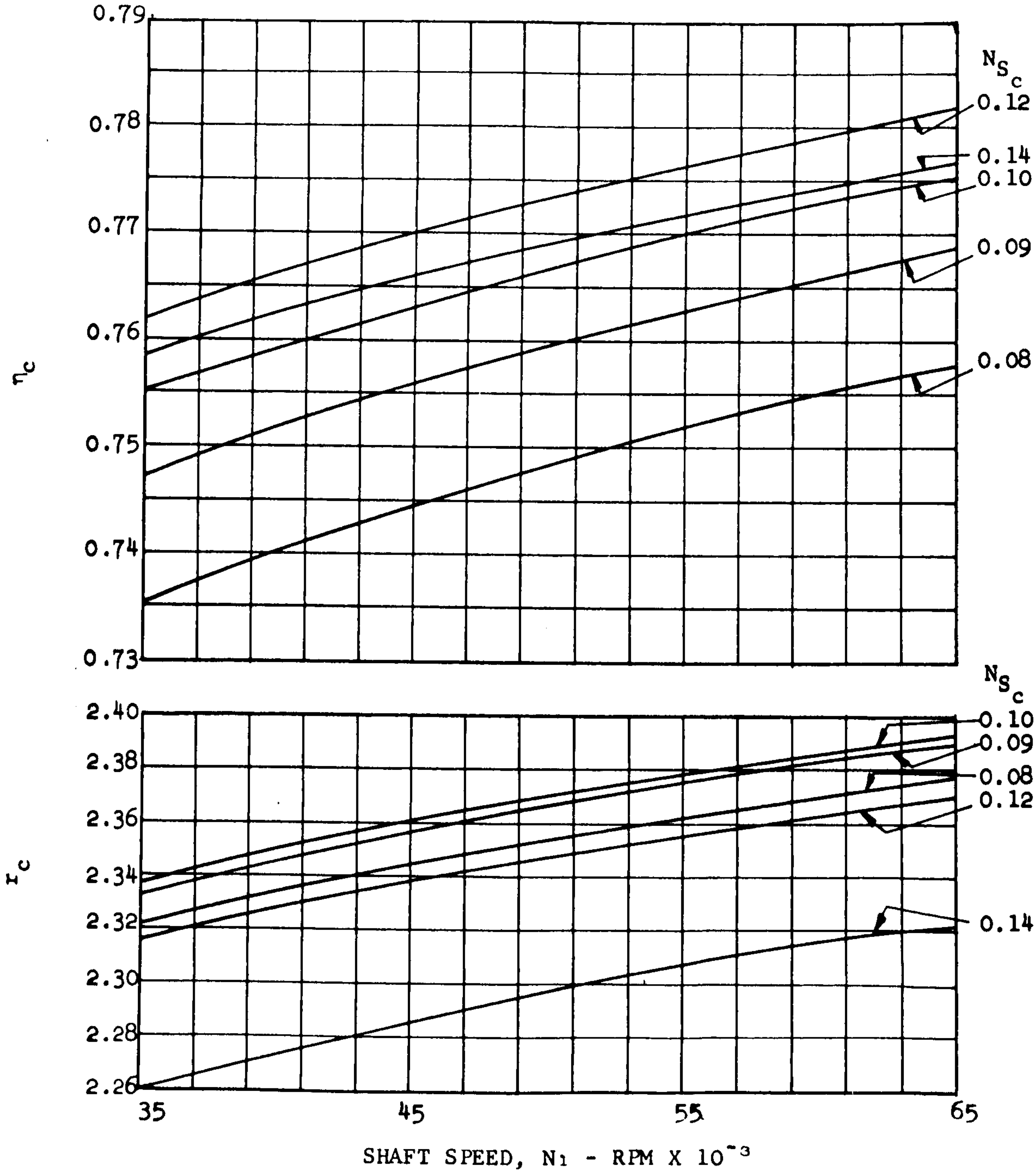


COMPRESSOR DIAMETER, COMPRESSOR INLET PRESSURE AND TURBINE INLET PRESSURE FOR OPTIMIZED NASA SYSTEM

FIGURE 8

A31495-1

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90

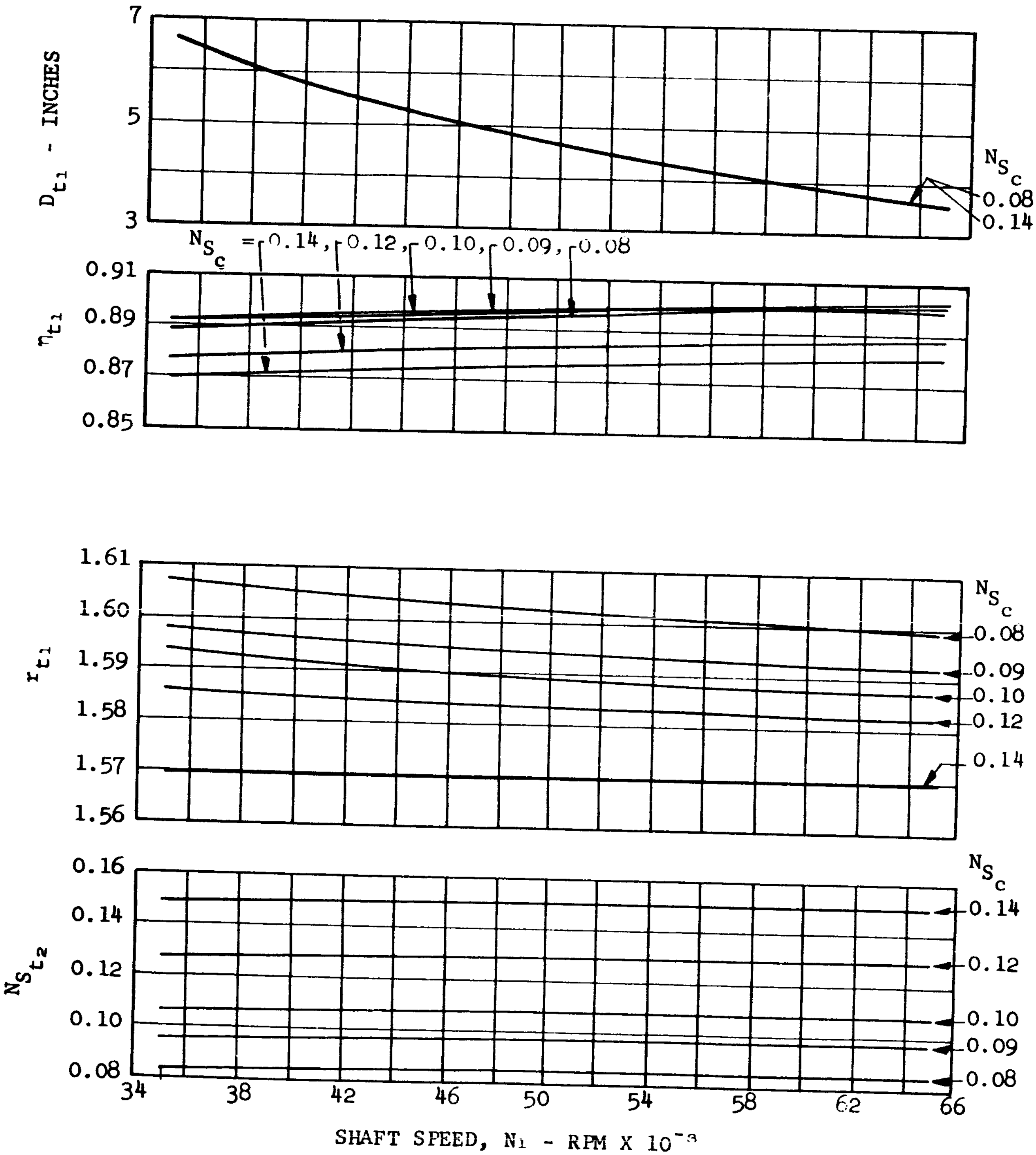


COMPRESSOR EFFICIENCY AND
COMPRESSOR PRESSURE RATIO FOR
OPTIMIZED NASA SYSTEM

FIGURE 9

A31496-1

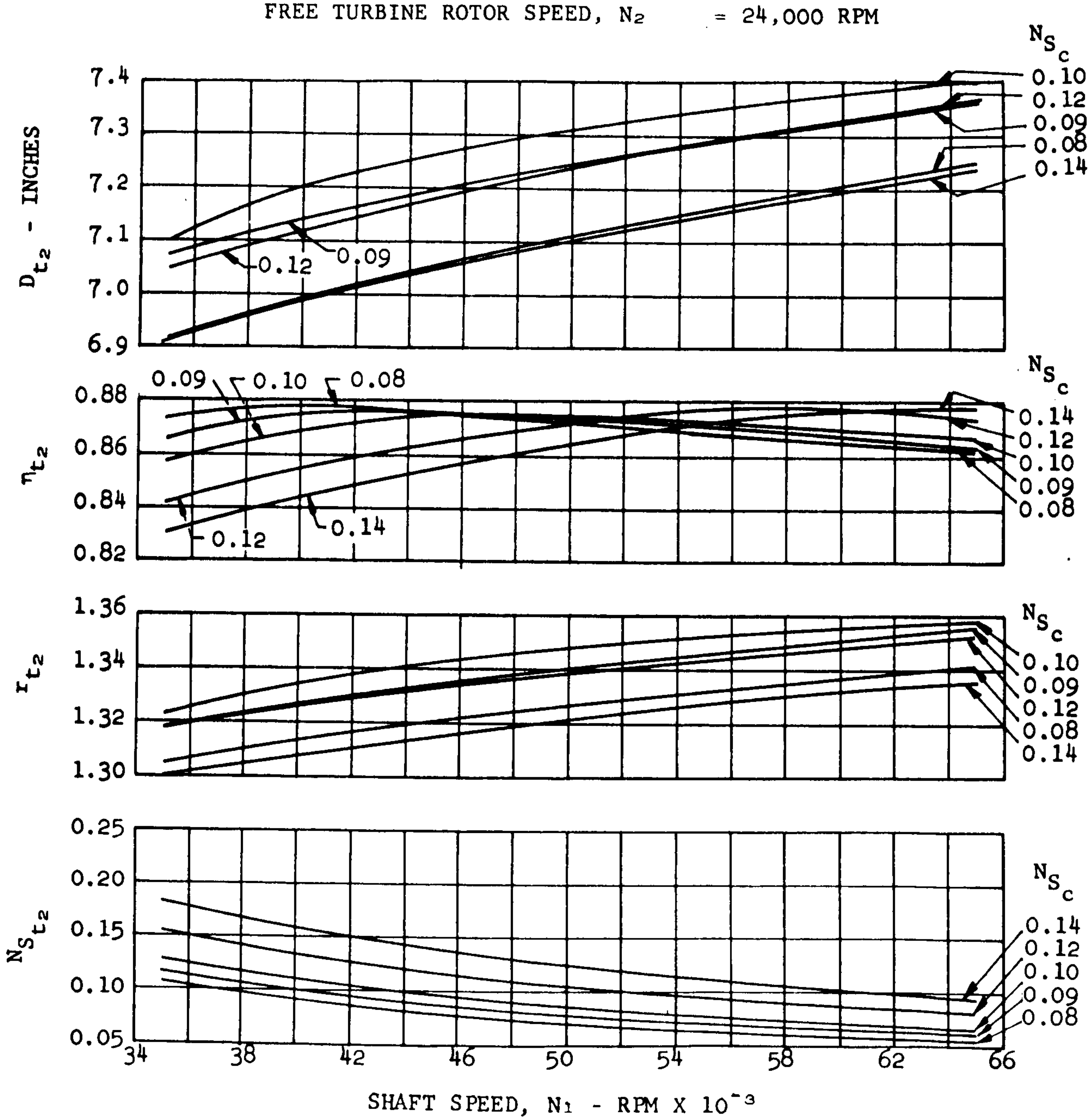
COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90
FREE TURBINE ROTOR SPEED, N_2 = 24,000 RPM



FIRST STAGE TURBINE
OPTIMIZED NASA SYSTEM
FIGURE 10

A31497-1

COMPRESSOR INLET TEMPERATURE, T_1 = 536°R
TURBINE INLET TEMPERATURE, T_3 = 1950°R
RECUPERATOR EFFECTIVENESS, E_R = 0.85
WORKING FLUID = ARGON
$\frac{\text{TURBINE PRESSURE RATIO}}{\text{COMPRESSOR PRESSURE RATIO}}$, β = 0.90
FREE TURBINE ROTOR SPEED, N_2 = 24,000 RPM



FREE TURBINE
OPTIMIZED NASA SYSTEM
FIGURE 11

A31498-1

A comparison was made between NASA design-point conditions at 38,500 rpm (6.0-inch wheels) and 45,000 rpm (5.1-inch wheels) and the "optimized" design-point conditions at 38,500 rpm (6.0-inch wheels), 45,000 rpm (5.25-inch wheels), and 55,800 rpm (4.3-inch wheels). Selected values of cycle parameters at these conditions appear in Table 2. In addition, the optimized conditions include both a high-cycle pressure cycle ($N_{s_c} = 0.08$) and a case with compressor specific speed comparable to the NASA design conditions.

The above design-point condition studies revealed no major advantage to be gained through a change in design-point conditions from those proposed by NASA. Some advantage in system weight and radiator area would be realized with increased shaft speed and pressure level; however, decreased wheel diameters would result. Therefore, it was recommended that the mass flow rate, compressor pressure ratio, compressor inlet pressure, and working fluid, as recommended by NASA, be established as design values with the gas generator shaft speed of 38,500 rpm.

TABLE 2

BRAYTON-CYCLE DESIGN PARAMETERS

	NASA		AiResearch Optimization					
N_1	38,500	45,000	38,500	38,500	45,000	45,000	55,000	55,000
N_{S_c}	0.106	0.123	0.08	0.10	0.08	0.10	0.08	0.10
η_{cy}	0.281 0.284	0.284 0.287	-- 0.272	-- 0.283	-- 0.277	-- 0.291	-- 0.281	-- 0.294
$\dot{m}$	0.611	0.611	0.531	0.530	0.517	0.517	0.504	0.501
KW_o	12.25 12.40	12.35 12.50	-- 10.45	-- 10.88	-- 10.40	-- 11.00	-- 10.34	-- 10.82
D_c	6.0	5.1	6.0	6.0	5.26	5.24	4.31	4.28
D_{t_1}	6.0	5.1	6.0	6.0	5.24	5.18	4.27	4.25
D_{t_2}	14.3 7.1	14.4 7.2	-- 6.97	-- 7.18	-- 7.05	-- 7.25	-- 7.15	-- 7.32
η_c	0.770	0.779	0.739	0.758	0.745	0.763	0.752	0.770
η_{t_1}	0.878	0.871	0.880	0.883	0.883	0.887	0.887	0.885
η_{t_2}	0.854 0.864	0.853 0.864	-- 0.877	-- 0.865	-- 0.875	-- 0.876	-- 0.868	-- 0.873
P_1	6.0	6.0	8.8	5.4	11.6	7.3	16.6	10.4
P_3	13.2	13.2	20.2	12.7	26.7	17.0	38.6	23.4
r_c	2.30	2.30	2.33	2.35	2.34	2.36	2.36	2.38
r_{t_1}	1.567	1.564	1.606	1.592	1.604	1.588	1.601	1.591
r_{t_2}	1.326	1.328	1.310	1.332	1.320	1.342	1.331	1.349
Vulnerable Area Factor	1.0	1.0	0.826	1.052	0.719	0.908	0.601	0.758

Table 3 presents the final design conditions used for the compressor. Design conditions as applicable to the gas generator configuration are given in Section 3.2.

TABLE 3

DESIGN CONDITIONS
NASA COMPRESSOR RESEARCH PACKAGE

Working fluid	Argon
Flow rate, lbs per sec.	0.621
Inlet temperature, $^{\circ}R$	520
Inlet pressure, psia	6.0
Total pressure ratio	2.30
Operating speed, rpm	37,900
Operating life, hr.	100
Speed capability, percent design	120

3.0 COMPRESSOR DESIGN

3.1 Aerodynamic Design Approach

The impeller diameter was fixed and a preliminary estimate was made of compressor efficiency and slip factor. After an approximate design was established, the compressor efficiency was calculated from a detailed loss analysis and the impeller diameter was modified accordingly.

The impeller inlet was sized to give the minimum inlet relative Mach number at the inducer tip. The shroud and hub profile were designed to give an accelerating flow along the wall from the inlet pipe to the impeller eye as well as a minimum velocity variation from hub to shroud across the inducer inlet section. Initially, a geometric shape of the inlet was selected and the velocity gradients determined by an analog field plot. Using these velocity gradients the velocity distribution was calculated. The geometric shape was altered until a suitable velocity distribution was achieved.

The impeller exit width was established so that the diffusion of relative velocity along the shroud, expressed as a ratio of relative velocities at the impeller inlet and the impeller exit, was less than 0.30. Also, the direction of flow at the diffuser inlet was determined to be not much larger than 60 degrees from the radial direction. With the inlet and exit dimensions fixed, the shroud and hub profile were assumed. Using the electric analog field plot method, with approximate corrections for compressibility, blade blockage and boundary layer clogging, the meridional velocities along several streamlines were calculated. The meridional shape was adjusted and the calculation repeated until a satisfactory distribution was obtained along the shroud and hub streamlines. Particular care was taken to insure that the shroud meridional velocity did not have too high a peak and that the hub velocity did not become so low as to cause negative velocities.

A slip factor of 0.869 based on temperature rise was used in the impeller design, however, the tangential component of velocity at the impeller exit was based on a value of 0.83, which is consistent with a windage loss of 3.9 percent. The value of slip factor used was based on experimental data and agrees closely with that obtained from Buseman's data for a 15 blade impeller.

Next, the blade loading diagram was estimated using a blade-to-blade calculation method. Utilized in these calculations were an assumed number of blades, an assumed blade angle variation, a calculated slip factor at the blade tip, and an estimated meridional velocity distribution. Since the blade elements were radial, the blade angles along the mean and hub streamlines were calculated from the value of the blade angles at the shroud.

Several combinations of blade angle distribution and numbers of vanes were checked until the following conditions were avoided:

(1) Excessive deceleration of relative velocity at the shroud.

(2) Very low or negative relative velocities at the hub.

(3) Excessive decelerations on the suction surface of any streamline.

The above blade loading calculations were based on the preliminary estimate of meridional flow distribution. The variation of meridional flow distribution due to the above blade loading was calculated using a high-speed digital computer and the blade loading was recalculated based on the modified meridional flow distribution.

In the present design, the original field plot meridional velocity distribution was modified according to past experience, before the blade loading calculation was made. This assumed meridional velocity distribution was very close to the corrected distribution and no iteration was necessary.

The loadings on the radial trailing edge portion of the blade were recalculated based on potential flow analysis. The results compared favorably with the previously calculated loadings.

The losses in the impeller were estimated using two-dimensional boundary layer techniques. The losses considered were blade and wall friction losses, mixin g losses due to boundary layer and blade wakes, impeller windage losses, and clearance losses. The Mach number was so low that there was no shock loss in the impeller.

In order to determine the diffuser geometry, equations were derived expressing the diffuser losses in terms of the variable parameters. The parameters considered were radius, diffuser exit vane angle, and number of vanes. The meridional width of the diffuser was allowed to increase from inlet to exit.

The exit core absolute velocity was held fixed at a value 0.6 times the inlet velocity. This was felt to be the maximum diffusion for which separation could be avoided. The required exit diffuser area was calculated to provide the specified diffusion, allowing for boundary layer growth and blade blockage, and the meridional width was adjusted to provide this area. The length of the diffuser vane, or the exit to inlet radius ratio of the diffuser was designed so that the equivalent conical or two-dimensional diffuser cone angle was somewhat less than the stall critical cone angle proposed by Kline.

The losses attributable to the diffuser are the friction losses and the loss of the kinetic energy associated with the radial component of velocity. The total loss was calculated for diffusers of various combinations of parameters and the optimum geometry was determined.

Finally, the blade core velocity districution was calculated using a potential flow analysis performed on a high-speed digital computer. The overall loading and the suction and pressure velocities were found to be acceptable.

Surface finish was specified for each component so that the surface was fluid dynamically smooth.

A family of scroll cross sections with different areas was selected for ease of manufacture and blending with the diffuser meridional shape. Using continuity and conservation of angular momentum and assuming inviscid flow, these cross sections were located circumferentially.

Next, the boundary layer thickness at each location was calculated. The area required at each circumferential section was increased by the boundary layer clogging and the original sections were relocated. The process was then repeated until reasonable convergence was obtained. The mean radius of each section was increased from the tang to the exit of the scroll so that considerable diffusion had taken place by the time the flow reached the exit of the scroll. The resulting exit mean Mach number is 0.16, low enough so that no further diffusion is deemed necessary before entering the heat exchanger upstream.

3.2 Aerodynamic Design

The following data and design information defines the impeller, the diffuser, and the scroll configurations resulting from the aerodynamic analysis of the compressor research package. The values are for the compressor design inlet conditions applicable to the gas generator configuration.

A. Efficiencies: See Table 4.

B. Pressure ratios:
   Total-to-total pressure ratio = 2.38
   Total-to-static pressure ratio = 2.575

C. Speed = 38,500 rpm

D. Specific work = 49.45 hp per lb per sec.

E. Weight flow = 0.611 lbs per sec.

F. Specific speed = 0.1057

G. Loss distribution: See Table 4.

H. Total and static pressures: See Table 4.

I. Total temperatures: See Table 4.

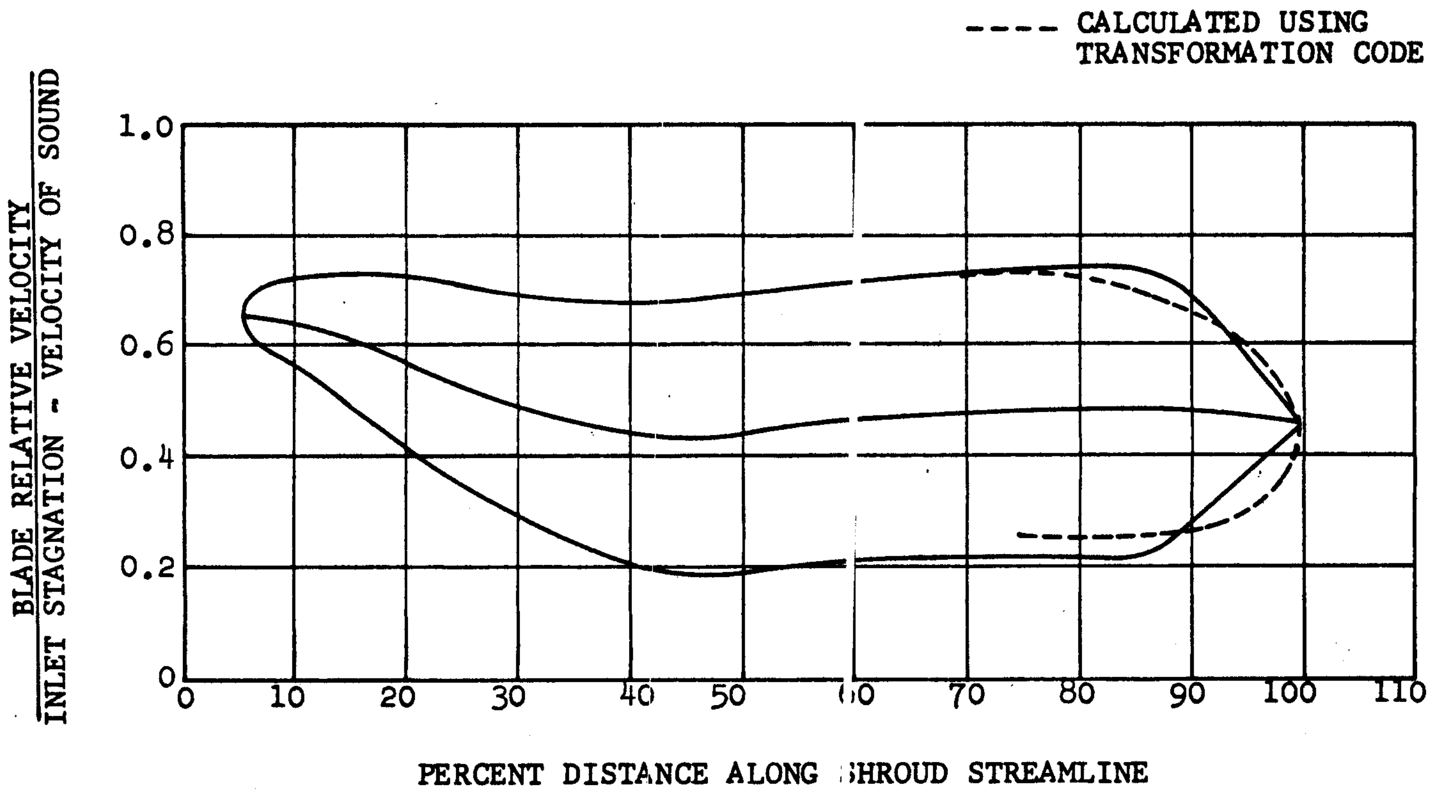
J. Gas velocity distribution:

   See Figure 12 for shroud velocity distribution.
   See Figure 13 for 50 percent streamline velocity distribution.
   See Figure 14 for hub velocity distribution.
   See Figure 15 for diffuser velocity distribution.

TABLE 4

NASA BRAYTON CYCLE COMPRESSOR
DESIGN VALUES

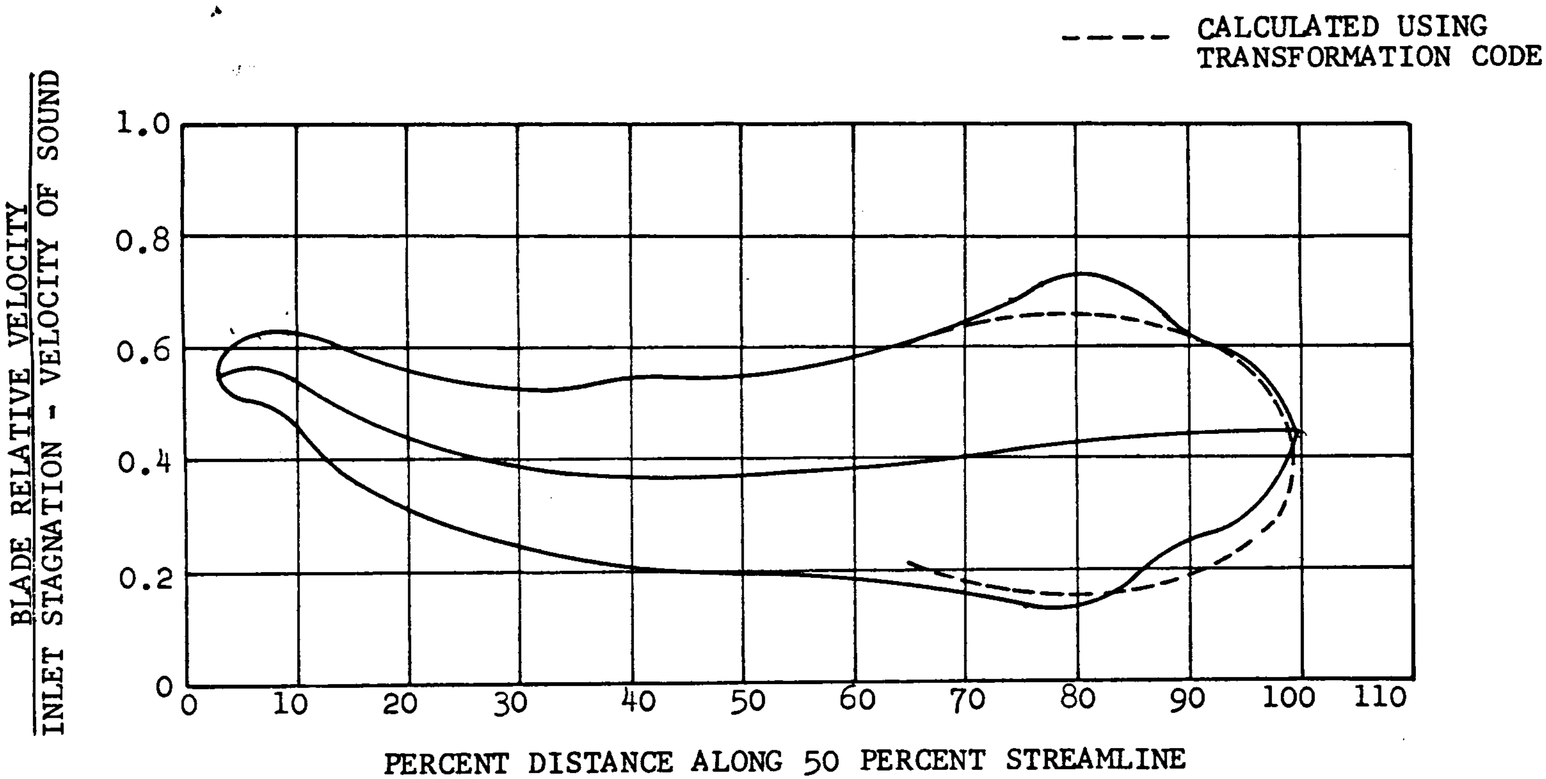
LOCATION	P_{TOT} (PSIA)	P_{STATIC} (PSIA)	T_{TOTAL} (°R)	η (UP TO LOCATION)
Inlet (Outside blade)	6.00	5.55	536	--
Impeller Exit (After B.L. and blade wake mixing)	15.72	9.70	817.3	0.896
Diffuser Inlet (Inside blade based on core velocity)	15.57	10.21	817.3	0.886
Diffuser Exit (Inside blade based on core velocity)	15.57	13.47	817.3	--
Scroll Inlet (Based on mean velocity after B.L. and blade wake mixing)	14.58	13.14	817.3	0.813
Scroll Exit (Based on mean velocity at scroll exit)	14.29	13.97	817.3	0.798



COMPRESSOR IMPELLER VELOCITY DISTRIBUTION
SHROUD STREAMLINE

A31544

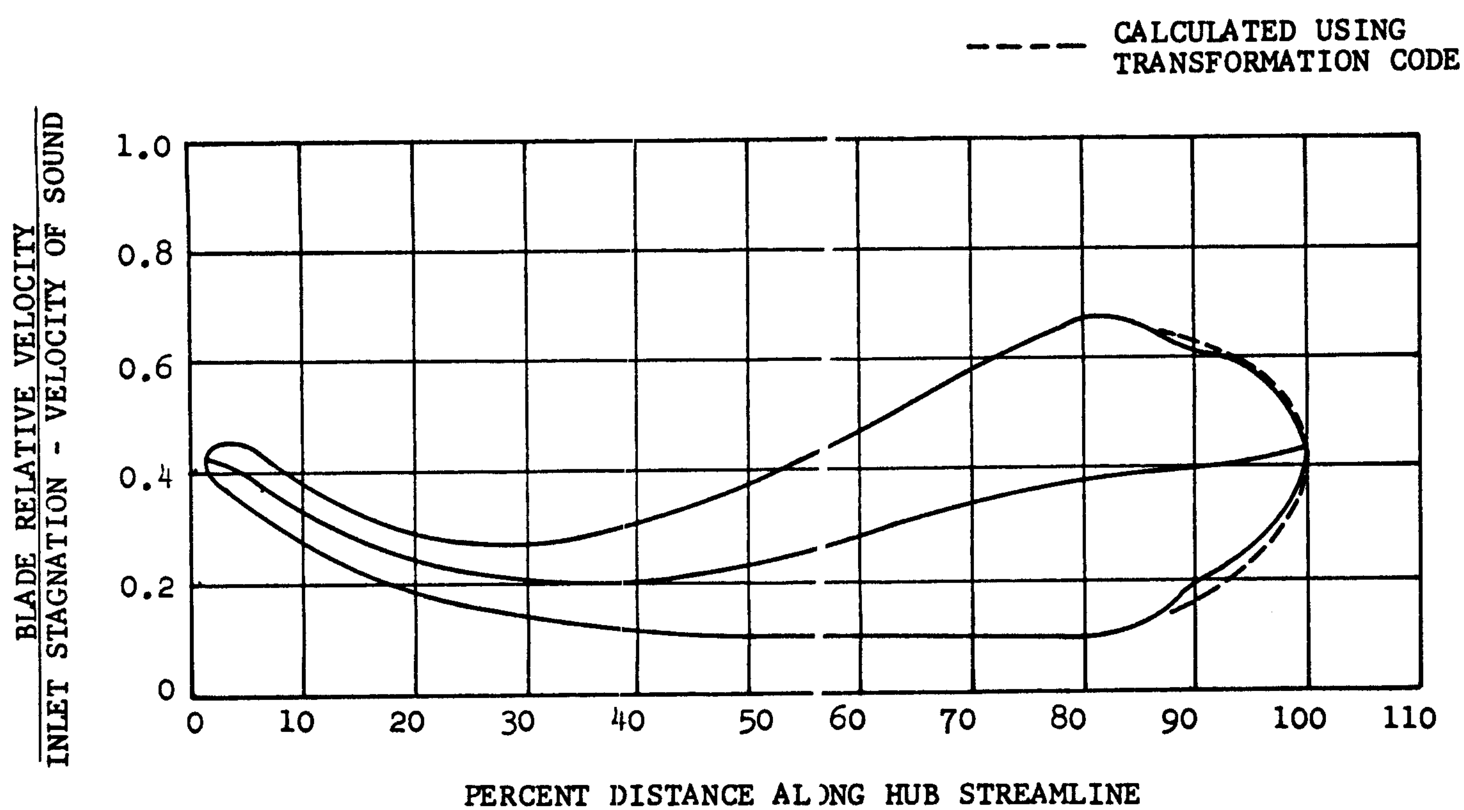
FIGURE 12



COMPRESSOR IMPELLER VELOCITY DISTRIBUTION
50 PERCENT STREAMLINE

FIGURE 13

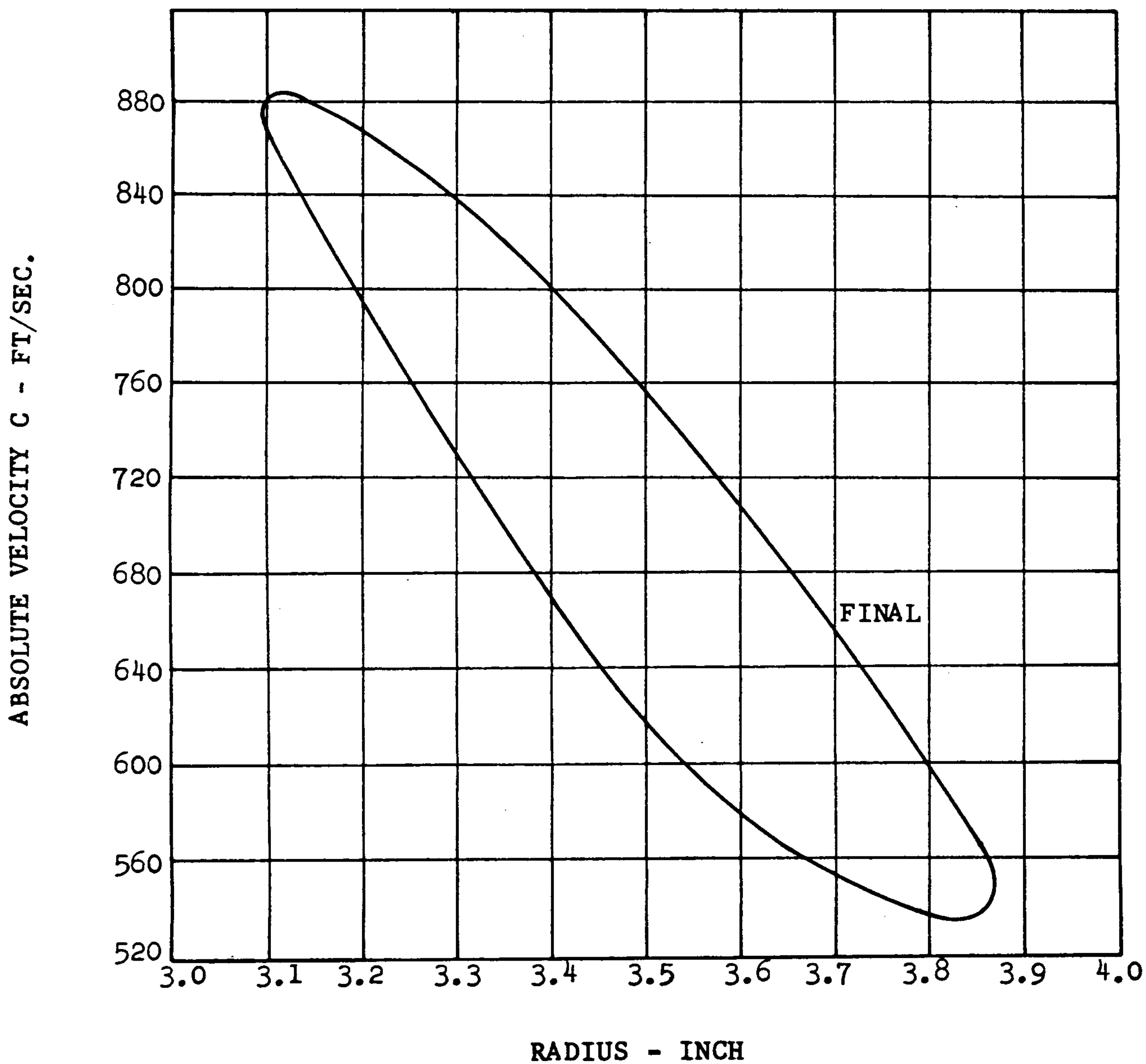
A31545



COMPRESSOR IMPELLER 'ELOCITY DISTRIBUTION
HUB STR:AMLINE

FIGURI: 14

A31546



COMPRESSOR DIFFUSER BLADE LOADING

FIGURE 15

A31547

K. Stator and rotor aerodynamic physical dimensions:

See Drawing 369757 for stator physical dimensions.

See Drawing 369747 for rotor physical dimensions.

See Drawing 369758 for diffuser physical dimensions.

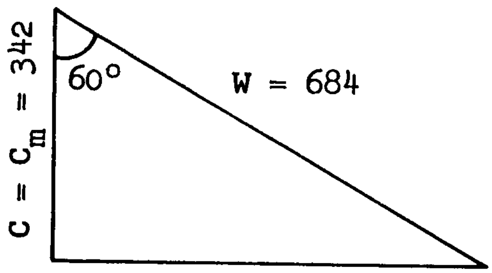
L. Velocity diagrams:

See Figure 16 for impeller velocity diagram.

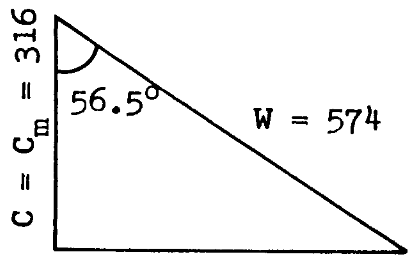
See Figure 17 for diffuser and scroll velocity diagrams.

FIGURE 16

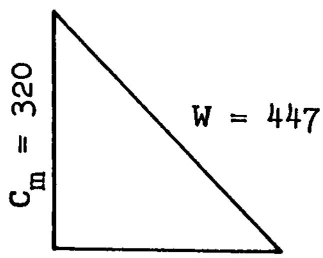
INLET VELOCITY TRIANGLES (JUST UPSTREAM OF LEADING EDGE)



INLET SHROUD



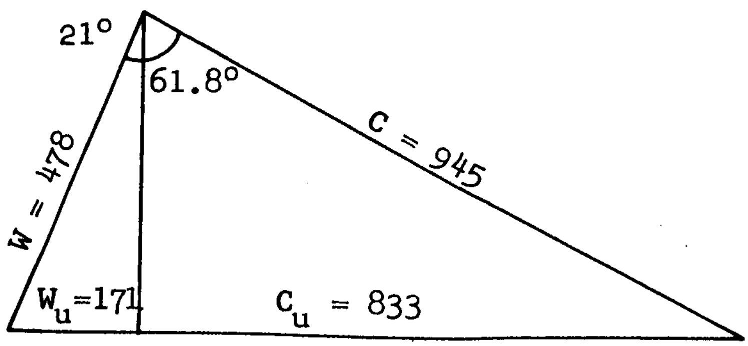
INLET MEAN



IMPELLER

INLET HUB

EXIT VELOCITY TRIANGLE (AFTER MIXING OF B. L. AND BLADE WAKES)

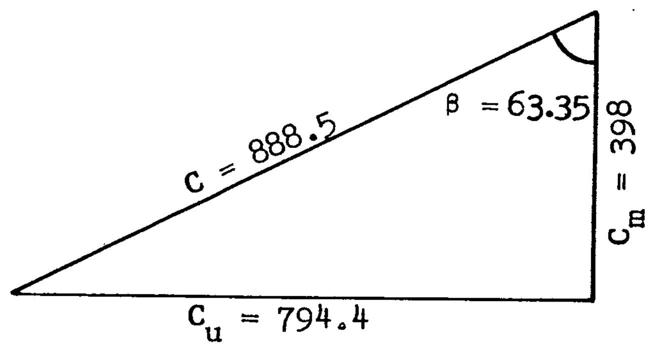


EXIT MEAN

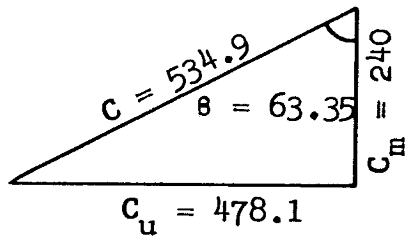
A31474

FIGURE 17

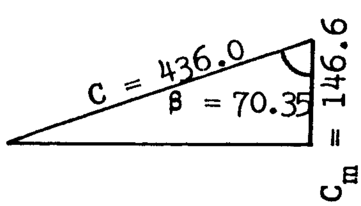
1. DIFFUSER INLET: (INSIDE BLADE AT R = 3.10 IN.)



2. DIFFUSER EXIT: (INSIDE BLADE AT R = 3.875 IN.)



3. SCROLL INLET: (AFTER MIXING OF DIFFUSER B.L. AND BLADE WAKES)



4. THE MEAN EXIT VELOCITY AT THE SCROLL EXIT IS 208.6 F/S YIELDING M_{exit} = .161

A31475

3.3 Mechanical Design Analysis

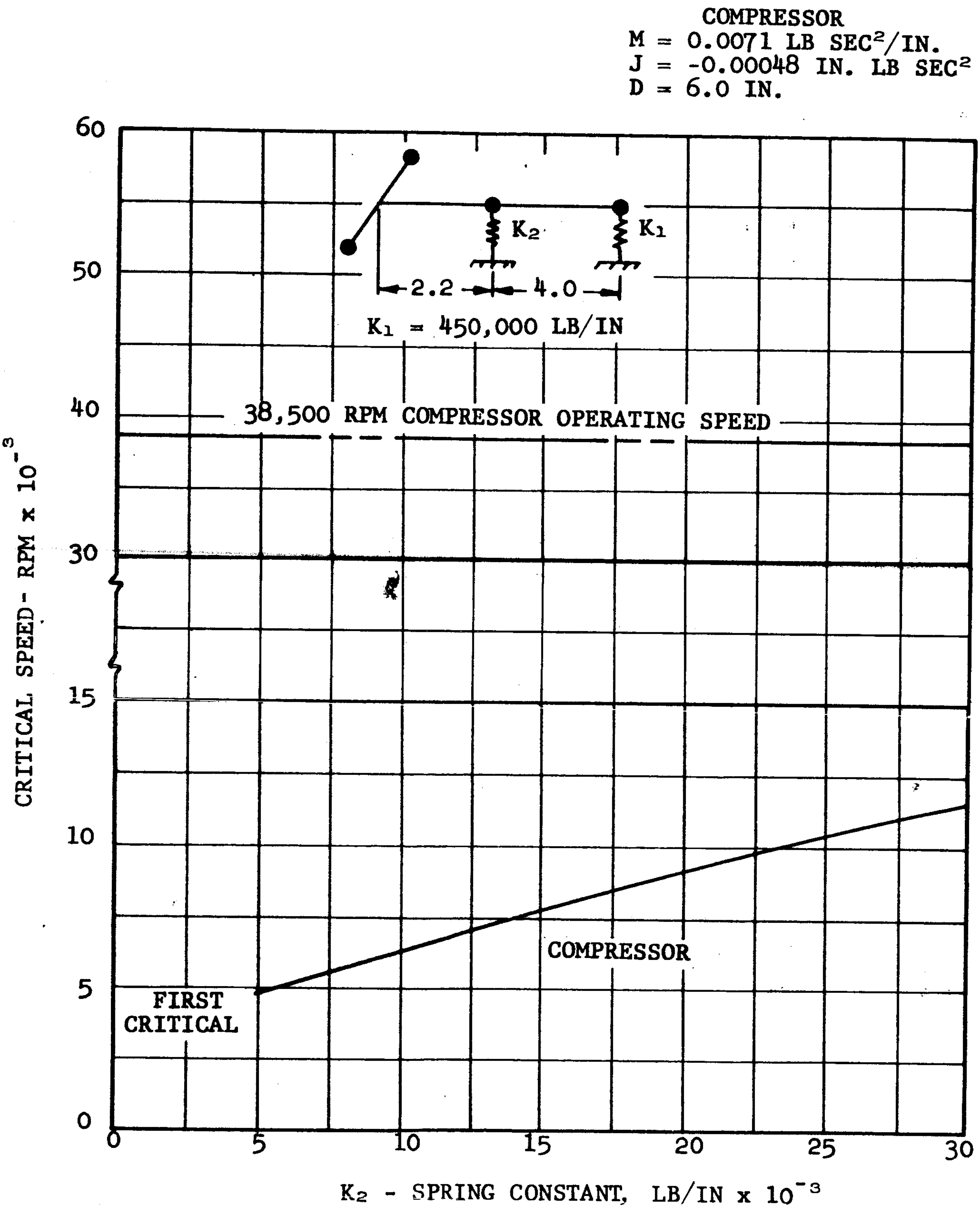
3.3.1 Dynamic Analysis

The dynamic analysis of the compressor research package was accomplished on a digital computer by use of a program written for turbomachinery critical speed and bearing load analyses. A 4.0-inch bearing spacing and 25-millimeter bearings were chosen for the research package. The rear bearing was rigidly mounted to limit the rotor radial motion within the required shroud clearance. This gave an effective spring rate of 450,000 pounds per inch for the rear mount. The critical speeds for the compressor were analyzed by using front bearing spring rates from 5,000 to 30,000 pounds per inch (see Figure 18). Using a front bearing spring rate of 15,000 pounds per inch, bearing loads for a 0.0005-inch c.g. eccentricity were determined. Figure 19 shows the results of the bearing load analysis.

3.3.2 Impeller Stress Analysis

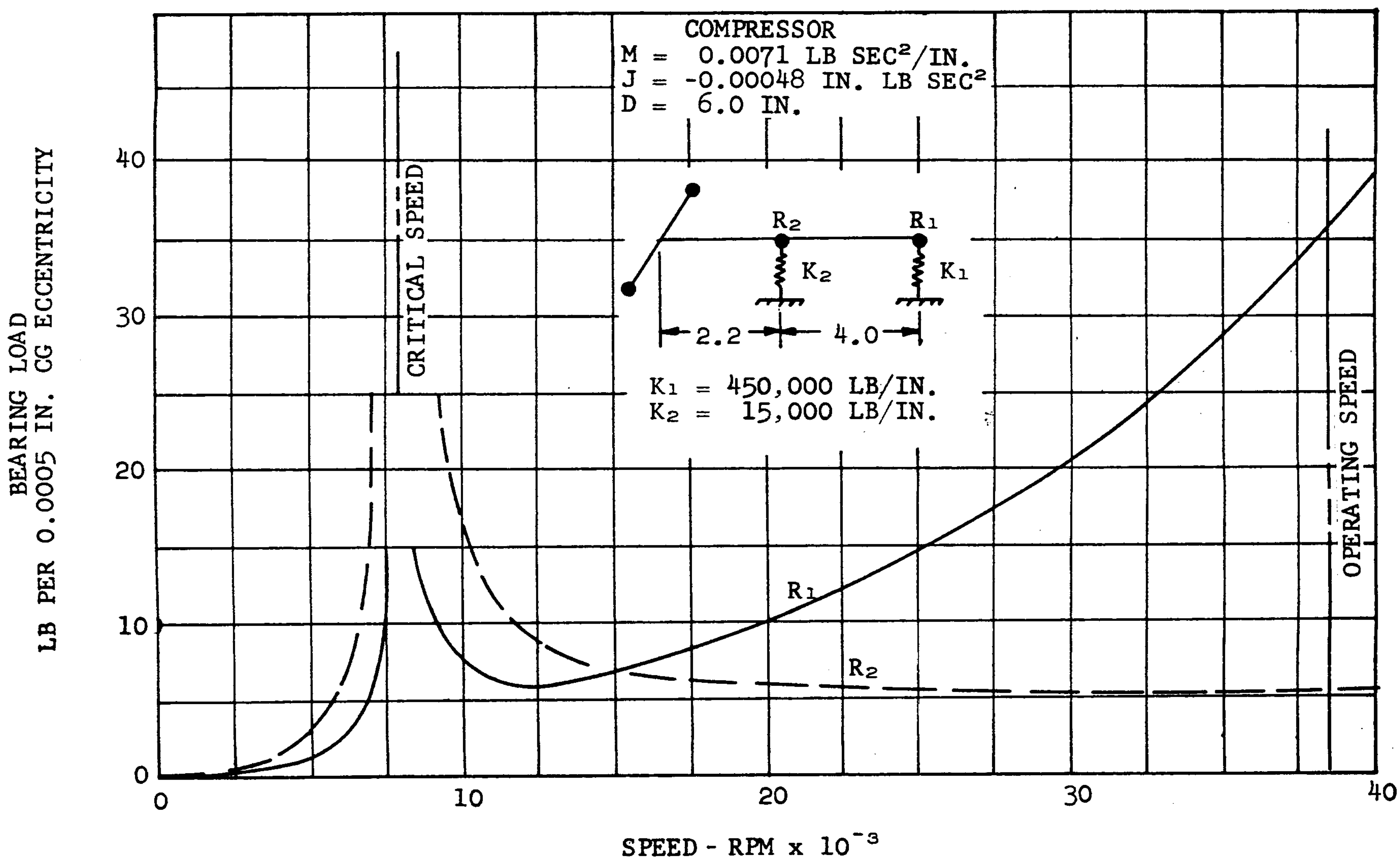
A stress analysis of the compressor wheel was performed for determining the centrifugal disc and blade stresses at the operating speed of 38,500 rpm. Disc stresses were calculated using the Bendix G-20 digital computer. Blade stresses were calculated using lamination theory. Radial and centrifugal stresses are plotted on Figures 20 and 21 respectively.

Yielding of the disc may be expected at a minimum speed of 82,000 rpm and in the blades at 122,000 rpm. The burst speed range may be expected to be between 119,000 rpm and 133,000 rpm.



CRITICAL SPEED VS. SPRING CONSTANT FOR
NASA COMPRESSOR RESEARCH PACKAGE
FIGURE 18

A30736-2

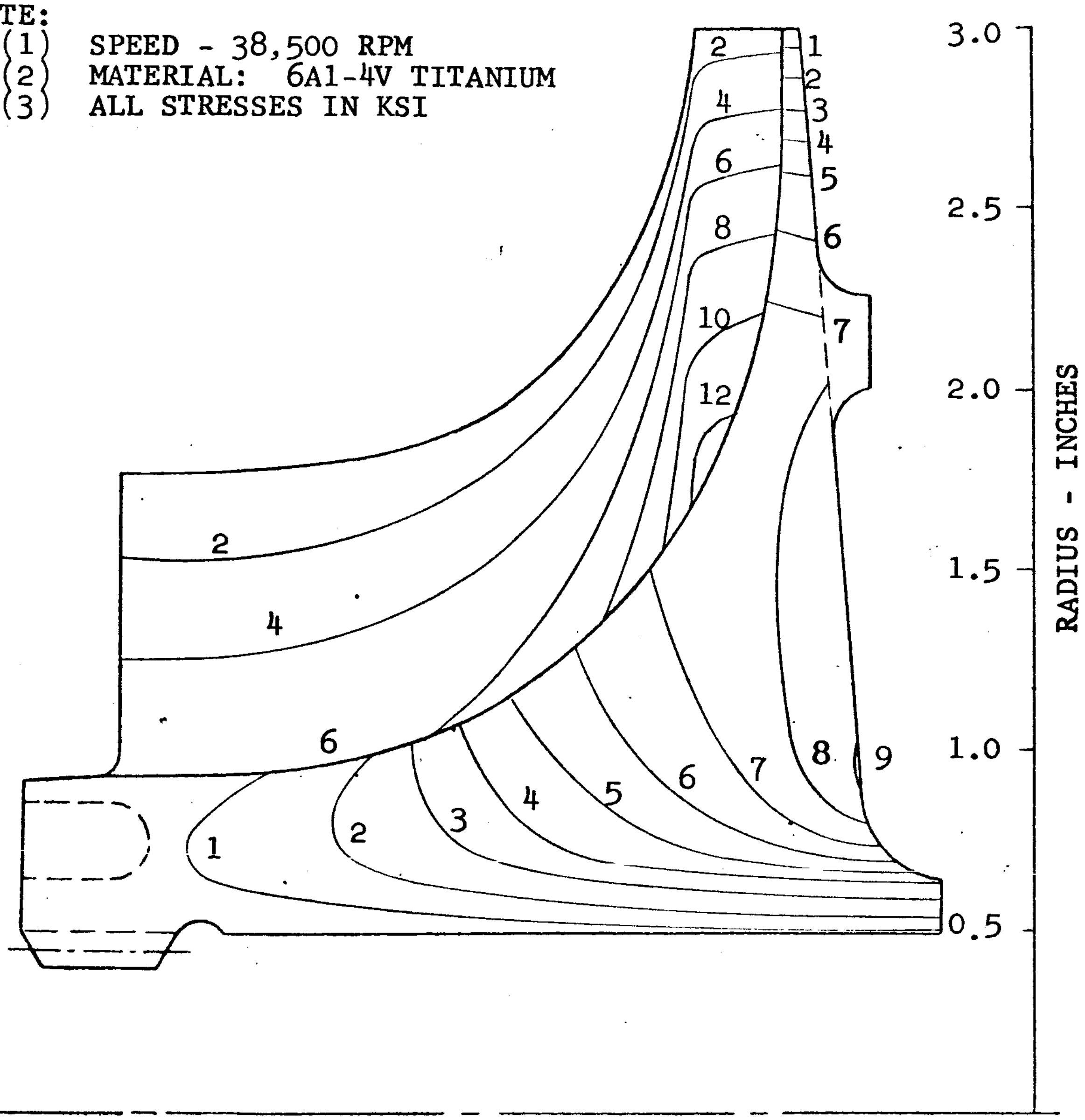


BEARING LOADS VS SPEED FOR
NASA COMPRESSOR BALL BEARING
TEST RIG WITH K_2 = 15,000 LB/IN.

A30737-1

FIGURE 19

NOTE:
(1) SPEED - 38,500 RPM
(2) MATERIAL: 6Al-4V TITANIUM
(3) ALL STRESSES IN KSI

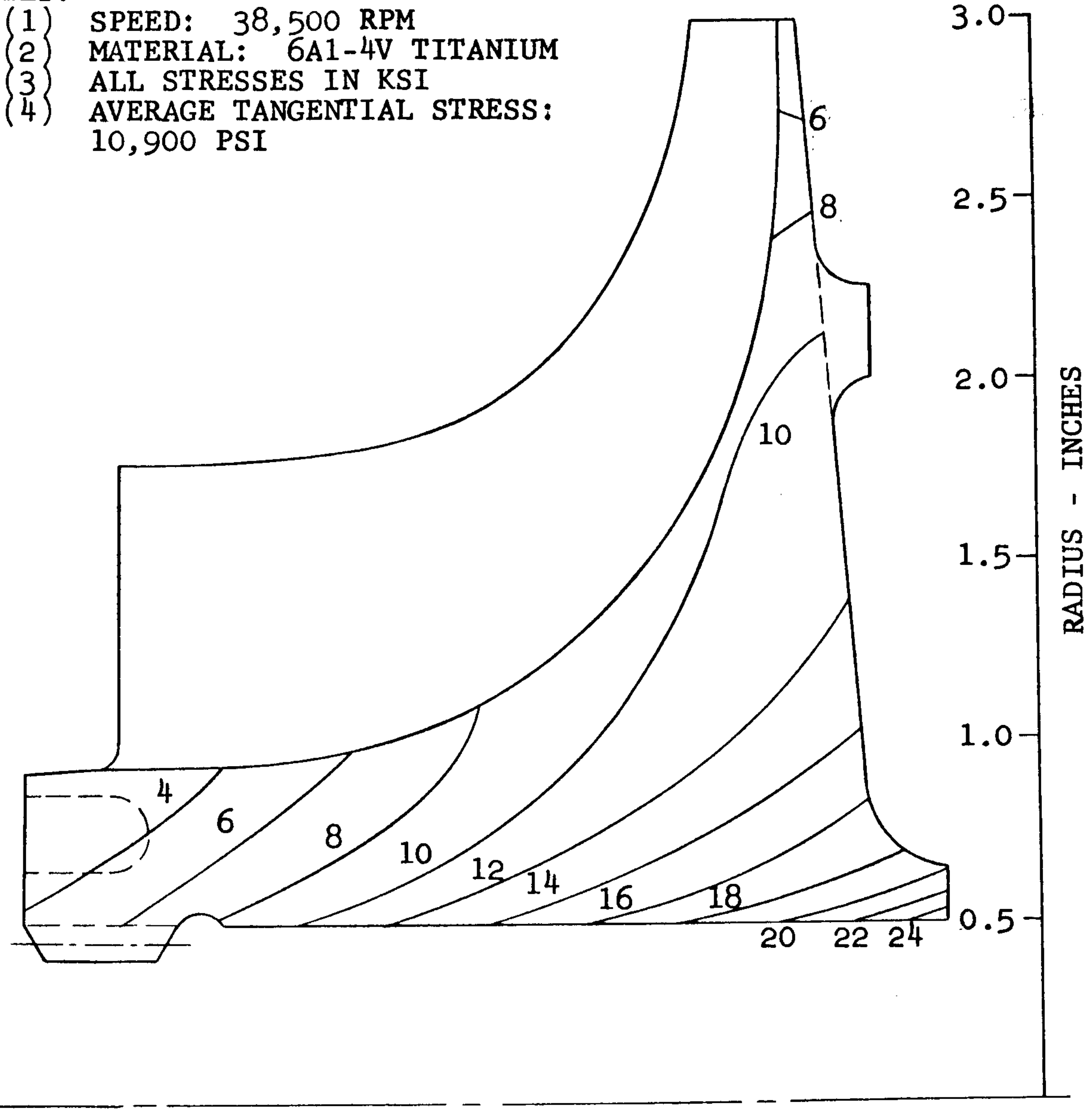


PREPARED	DW	10-63	RADIAL STRESS DISTRIBUTION FOR NASA BRAYTON-CYCLE IMPELLER	A12037
WRITTEN				
APPROVED	RVN.	10-63	AiResearch Manufacturing Company of Arizona	

FORM P793A-1

FIGURE 20

NOTES:
(1) SPEED: 38,500 RPM
(2) MATERIAL: 6A1-4V TITANIUM
(3) ALL STRESSES IN KSI
(4) AVERAGE TANGENTIAL STRESS: 10,900 PSI



PREPARED	DW	10-63	TANGENTIAL STRESS DISTRIBUTION NASA BRAYTON CYCLE IMPELLER	A12038
WRITTEN				
APPROVED	R.W.M.	10-63	AiResearch Manufacturing Company of Arizona	

FORM P793A-1

FIGURE 21

Since creep of the titanium alloy is negligible at the temperatures encountered in this application, the impeller may be considered essentially an infinite life wheel.

The wheel was machined from a 6 Al-4V titanium forging and piloted on the shaft (rather than on the splines) with a 0.0003 to 0.0006 inch diametral interference

3.3.3 Stresscoat Growth and Burst Tests

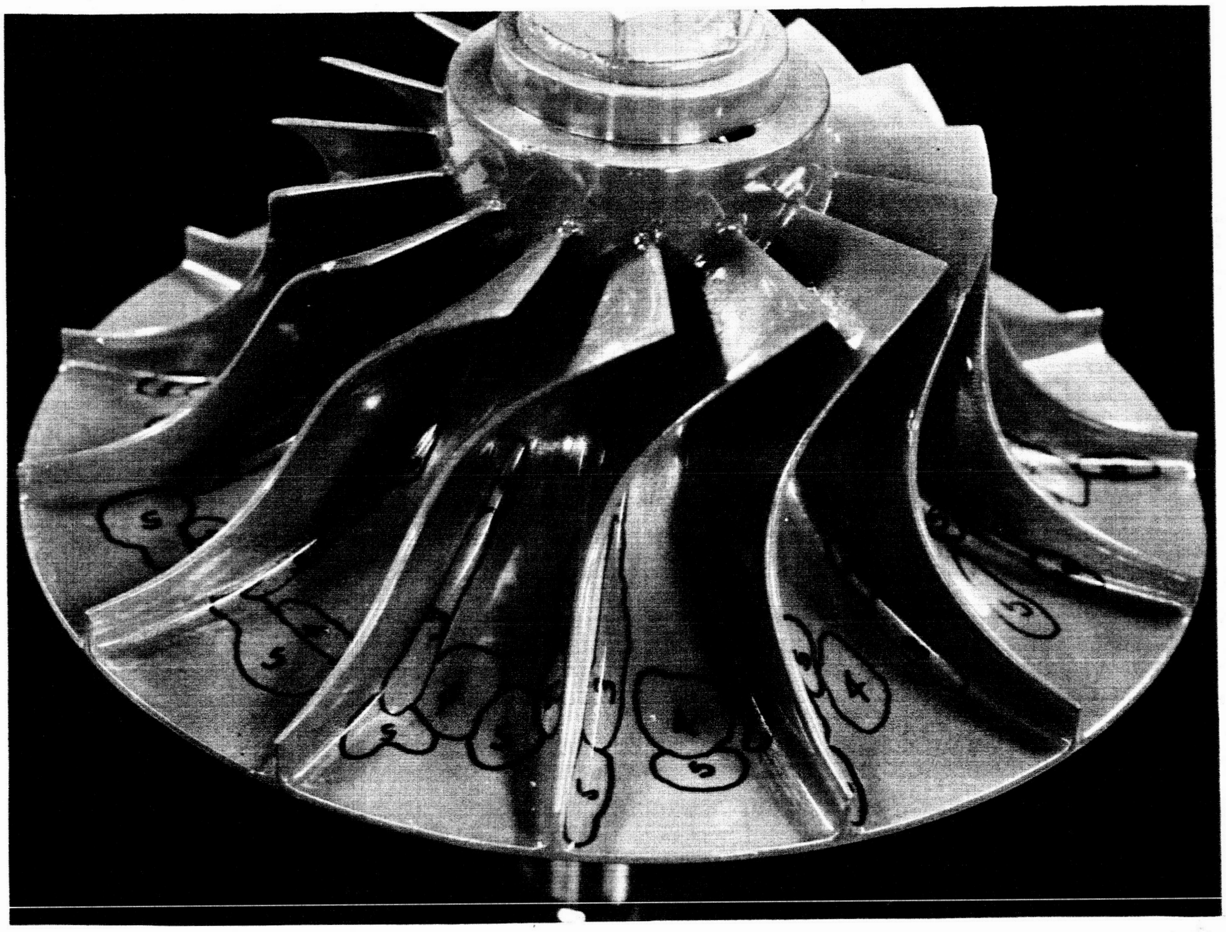
Results of the Stresscoat test conducted on the compressor impeller are shown in Figures 22 and 23. The maximum stress at 38,500 rpm as indicated by the Stresscoat in Figure 22, Area 1, was 21,200 psi. The maximum calculated stress in the hub was 24,800 psi at an area covered by the arbor. Calculated stresses of approximately 20,000 psi in the hub radius correspond closely with the Stresscoat results, as does the Stresscoat results for the remainder of the back face. The maximum radial stress in the blade indicated by the Stresscoat was 14,400 psi at 38,500 rpm compared to a calculated value of 13,200 psi.

A growth test was conducted on the subject wheel with residual diametral deformations recorded for the OD and for the ID at both the spline (inducer) end and the bearing (hub) end. Results of this test are shown in Figure 24. In an attempt to burst the wheel, substantial growth of the ID (0.026- to 0.030-inch residual deformation) occurred and allowed the c.g. of the wheel to shift relative to the arbor. Violent precession resulted, and the wheel dropped in the whirlpit (see Figure 25) at 124,000 rpm. This speed falls within the calculated burst speed range of

STRESSCOAT TEST OF NASA BRAYTON-CYCLE
COMPRESSOR WHEEL, PART 369747
STRESSES BELOW ARE FOR UNIAXIAL STRESSES AT 38,500 RPM.
ESTIMATED ACCURACY OF STRESSES: ±20 PERCENT.
AVERAGE STRESSCOAT SENSITIVITY: 0.0007.
MATERIAL: 6Al-4V-90 TITANIUM ALLOY.
$E = 16.0 \times 10^6$ PSI
MARCH 6, 1964

AREA	STRESS (PSI)
1	21,200
2	17,300
3	14,400
4	11,950
5	9,850

FIGURE 22



STRESSCOAT TEST OF NASA BRAYTON-CYCLE
COMPRESSOR WHEEL, PART 369747
STRESSES BELOW ARE FOR UNIAXIAL STRESSES AT 38,500 RPM.
ESTIMATED ACCURACY OF STRESSES: ±20 PERCENT.
AVERAGE STRESSCOAT SENSITIVITY: 0.0007.
MATERIAL: 6Al-4V-90 TITANIUM ALLOY.
$E = 16.0 \times 10^6$ PSI
MARCH 6, 1964

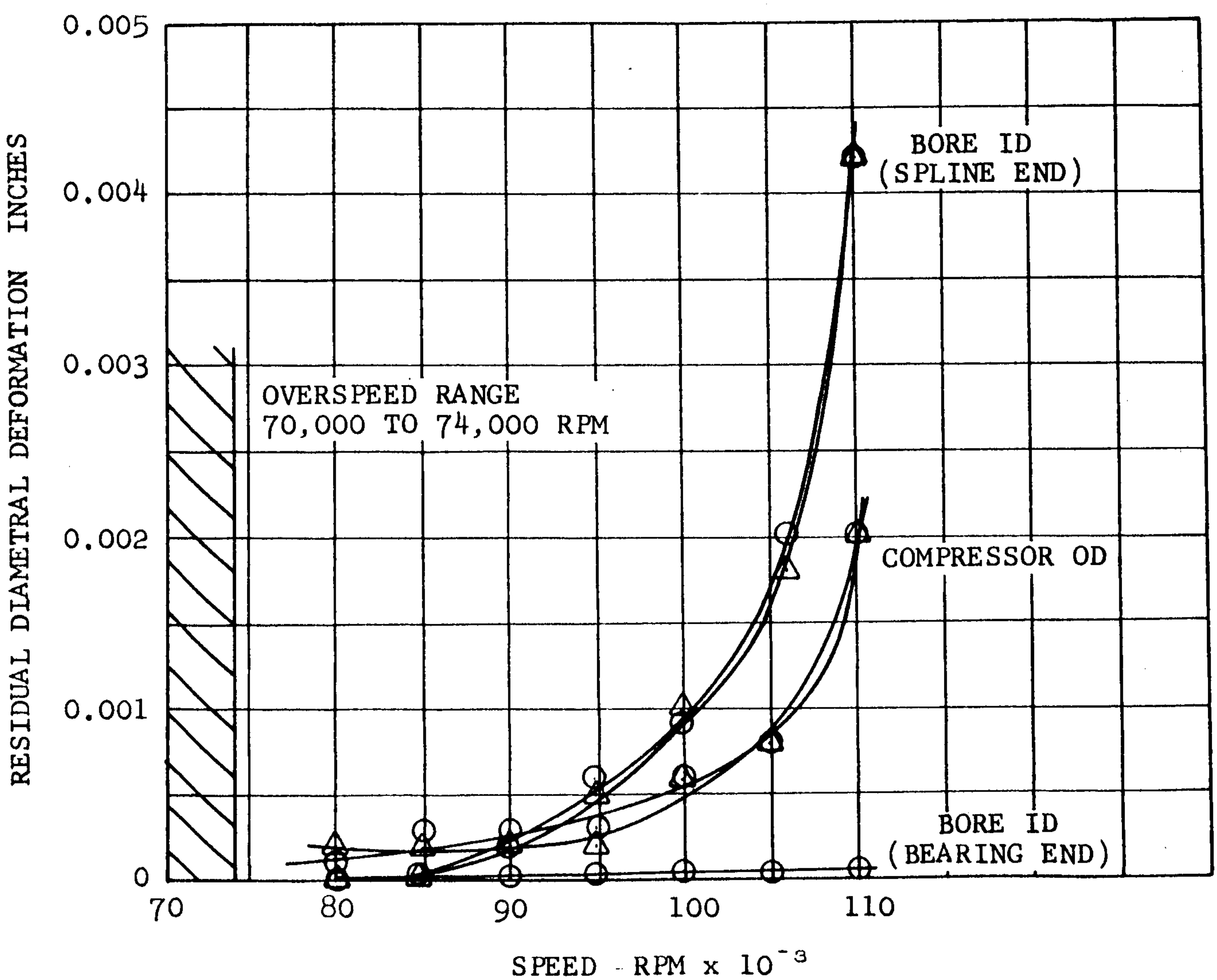
AREA	STRESS (PSI)
1	21,200
2	17,300
3	14,400
4	11,950
5	9,850

FIGURE 23

S/N 4X 101
MATERIAL: 6 Al - 4V - TITANIUM
⊙ AND ⚠ INDICATE MEASUREMENTS TAKEN AT RIGHT ANGLES

PRERUN DIAMETERS:

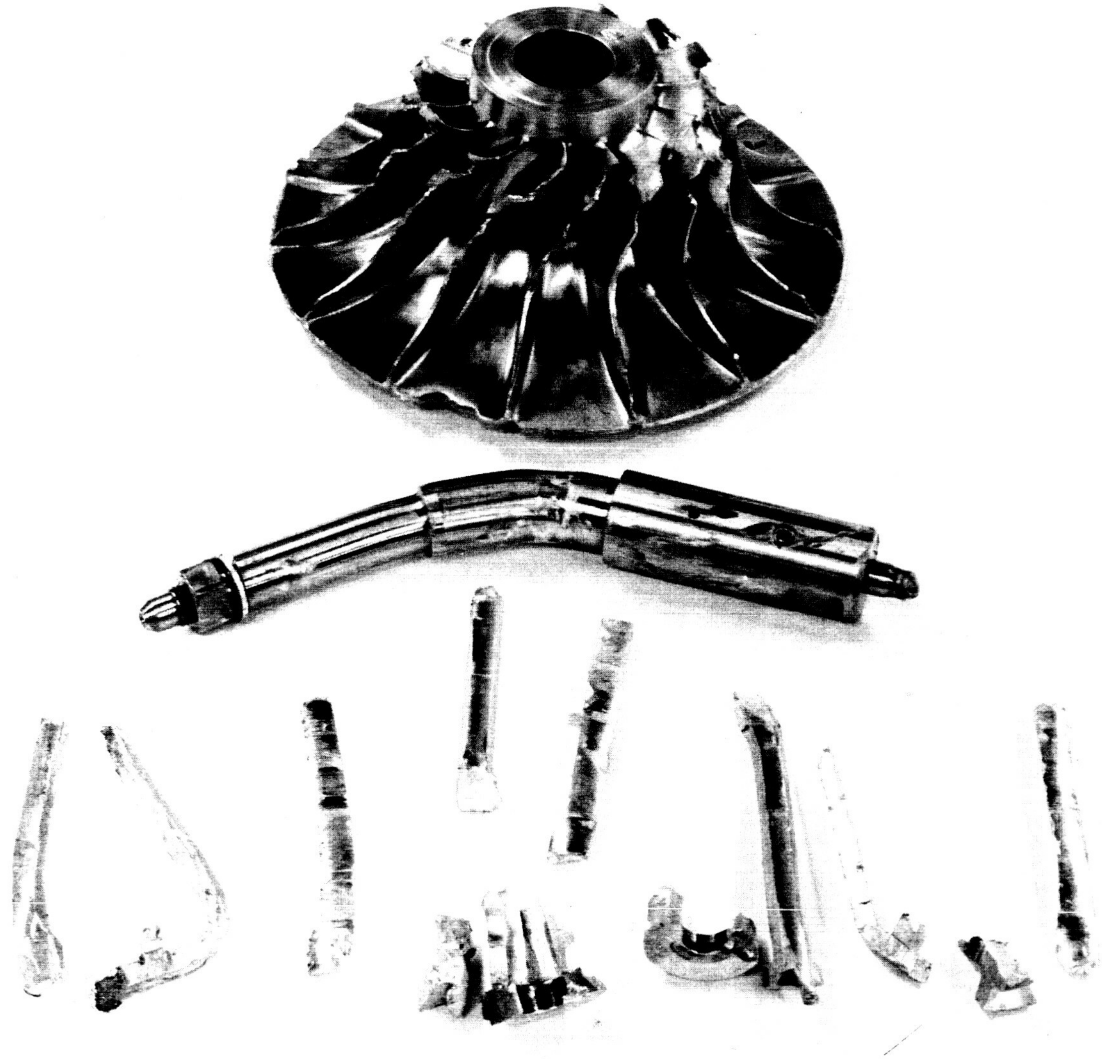
COMP. OD	5.9800 AND 5.9799	
BORE ID	0.9841 AND 0.9842	(BEARING END)
BORE ID	0.9847 AND 0.98475	(SPLINE END)



GROWTH OF NASA BRAYTON CYCLE COMPRESSOR WHEEL

A60261-1

FIGURE 24



BURST TEST RESULTS
NASA COMPRESSOR IMPELLER

FIGURE 25

119,000 to 133,000 rpm; and while actual fracture of the wheel did not occur because of the large elongation of the material, the burst speed is in excess of the minimum calculated value, and a rerun of the burst test is not considered necessary.

3.4 Mechanical Design

3.4.1 General Unit Description

A cross-sectional view of the compressor research package is shown in Assembly Drawing 369731. The unit consists of the compressor impeller (369747) and shaft (369754) mounted in the main housing (369722) on two antifriction bearings (358313). The front bearing (impeller end) is resiliently mounted with a spring rate of 15,000 pounds per inch using the bearing mount described in Drawing 369733. This spring rate was chosen so that the first critical speed could be far removed from the operating speeds. Bearing loads are also small. The rear bearing is rigidly mounted to limit the impeller-to-shroud clearances, and a coil spring (111917) provides 30 pounds of axial preload on the bearings. An oil jet (369728) supplies pressurized oil to each bearing, and a carbon-face-type oil seal (358319 and 358321) is provided at each end of the housing. The impeller end seal (358321) has an argon purge chamber located between the face seal and an annular shaft seal to prevent any minute amount of oil leakage past the face seal from contaminating the system argon. A spline-connected stub shaft (369746) located at the input end of the compressor permits adaptation to an external power source.

The compressor diffuser (369758) and the scroll assembly (369757) attach to the main housing by a bolted flange. Shimming to obtain the desired compressor-wheel-shroud-face clearance is accomplished at this flange be providing a shim of predetermined thickness between the housing and the scroll flanges (369745). A compromise value of the clearance was established at 0.010- to 0.012-inch. From an aerodynamic consideration, a zero clearance would be optimum, however, a clearance of 0.002 inches per inch of wheel diameter can be utilized without serious performance penalty. From a mechanical consideration, it is advantageous to maintain large clearances so that, with rotor radial and axial displacements due to tolerance stackup and flexible-bearing displacements, the rotor does not rub on the shroud. Sealing at this shim is accomplished with two O-rings (369813). Bolted flanges at the compressor inlet and discharge permit adaptation of appropriate ducting (369778 and 369779). A rigid mounting base (369752) provides for mounting the compressor research package to a test stand bed plate. Table 5 is a summary of the parts used on the compressor research package.

3.4.2 Instrumentation

Provisions were made for providing certain instrumentation on the compressor as follows:

(a) Inlet

- (1) Three static pressure taps in the same plane, 120 degrees apart.
- (2) Three total pressure taps, 1/2-inch downstream of the static pressure taps, 120 degrees apart.

(b) Rotor

- (1) One L.C. Smith probe mount, 0.3 inch upstream of the rotor leading edge.

TABLE 5

NASA COMPRESSOR RESEARCH PACKAGE DRAWING AND PARTS LIST

DRAWING OR PART NUMBER	TITLE	USED ON	NUMBER REQUIRED
369730	Compressor Outline, Test, Brayton Cycle		
369731	Compressor Assembly, NASA		
369722	Housing Assembly, Main	369731	1
369723	Spacer	369731	1
369727	Carrier, Seal	369731	1
369728	Nozzle Assembly, Oil	369731	1
369729	Spacer, Labyrinth (Optional)*	369731	1
369732	Spacer, Bearing	369731	1
369733	Mount, Bearing, Resilient	369731	1
369734	Carrier, Bearing	369731	1
369735	Carrier, Bearing	369731	1
369737	Carrier Assembly, Labyrinth Seal (Optional)	369731	1
397738	Carrier Assembly, Carbon Seal	369753	1
369743	Shim, Bearing Carrier	369731	As required
369744	Shim, Seal	369731	As required
369745	Shim, Sealing Spacer	369731	1
369746	Shaft, Quill**	369731	1
369747	Impeller, Compressor	369731	1
369752	Shaft Assembly, Mounting	369731	1
369753	Seal Assembly, Carbon	369731	1
369754	Shaft Assembly, Impeller	369731	1
369757	Scroll Assembly, Compressor	369731	1
369758	Diffuser, Compressor	369731	1
369759	Shim, Housing, Diffuser	369731	1
369770	Spinner, Impeller	369731	1
369771	Washer, Flat	369731	1
369778	Flange, Compressor Outlet**		1
369779	Flange, Compressor Inlet**		1
369813	Seal, O-Ring	369731	1
111917	Spring, Compression	369731	1
358313	Ball, Single Row, Angular Contact	369731	2
358319	Seal, Air-Oil	369731	1
358320	Seal, Argon, Oil-Metal Bellows (Optional)	369731	1
358321	Seal Set, Gas-Oil, Matched	369753	1
	COMMERCIAL PARTS		
MS16555-617	Pin	369722	2
MS16555-625	Pin	369722	3
MS16555-646	Pin	369752	2
MS21045-C5	Nut	369731	12
MS24630-2	Type "F" Screw	369731	2
MS24673-2	Screw	369731	12
MS24673-5	Screw	369731	4
MS29561-015	O-Ring	369731	2
MS29561-235	O-Ring	369731	1

*Parts marked (optional) may be used as an alternate.

**These parts are shipped loose to the customer. The flanges are to be welded into the customer's inlet and exhaust ducting.

TABLE 5 (Cont'd)

DRAWING OR PART NUMBER	TITLE	USED ON	NUMBER REQUIRED
AN3CH5A	Screw	369731	6
AN5C-12	Screw	369731	12
AN6CH10A	Screw	369731	4
AN816-5-4S	Connector	369728	1
AN960C516L	Washer	369731	12
AN960C616	Washer	369731	4
S8152AT101-0-120	Pin Diam = 0.0469; Length = 0.120; Material: SAE 4340 Both ends chamfered 45° x 0.008; Hardness - R_c 40	369734	1
S8152AT101-0-220	Pin Diam = 0.0469; Length = 0.220; Material: SAE 4340 Both ends chamfered 45° x 0.008; Hardness - R_c 40	369733	1
S8152BG17-0-590	Pin	369738	2
S8152BG17-0-590	Pin Diam = 0.2032; Length = 0.590; Material: 321 Cres Steel Both ends chamfered 45° x 0.015; Condition: A annealed	369737	2
S8152BG40-0-310	Pin Diam = 0.2500; Length = 0.310; Material: 321 Cres Steel Both ends chamfered 45° x 0.025; Condition: A annealed	369728	1
S8171AP102	Packing "O" Ring Dia of "O" Ring = 7,445. Dia of Ring Material = 0.137 Material: MIL-R-25897 Type I, Class 1 (Viton "A" Material)	369731	1
S8860C1P1	Plate, Identification Thickness: 0.016 Material: 301 Cres Steel Condition: 1/2 Hard	369731	1
362-506-9012	Gasket - Metal O-Ring 3/32-inch tube, 0.010-inch wall Ring OD = 5.252 inch Vendor: The D.S.D. Manufacturing Company, Hamden, Connecticut, Fed Sup Code 97968, Vendor Part No. C5250C-AG	369731	1
362-522-9002	Gasket - Metal O-Ring 1/16-inch tube, 0.010-inch wall Ring OD = 0.502 inch Vendor: The D.S.D. Manufacturing Company, Hamden, Connecticut, Fed Sup Code 9796B, Vendor Part No. A0500C-AG	369731	2
525-518-9047	Nut, Self-Locking, Hex, Thin, 750°F Thread: 3/4 - 16 NF-3 Vendor: Standard Press Steel Co, Jenkintown, Pennsylvania, Fed Sup Code 56878, Vendor Part No. 50FK1216	369731	1
525-577-9006	Nut, Self-Locking, Round, Bearing Retaining Nominal OD = 1 9/16 inch Vendor: Shur-Lok Corporation, Anaheim, California, Fed Sup Code 97393, Vendor Part No. S658N05C	369721	1
655-601-9208	Screw, Self-Locking, Socket, Head, 1200°F Length: 0.50 Vendor: Long-Lok Corp., Los Angeles, California, Fed Sup Code 03038, Vendor Part No. DT 100000-82-8	369731	1

(2) Three sets of five static pressure taps along the rotor shroud, each set 120 degrees apart.

(c) Diffuser

Two sets of five static pressure taps along the diffuser 50 percent streamline, one set one each side of the diffuser passage.

(d) Scroll Exit

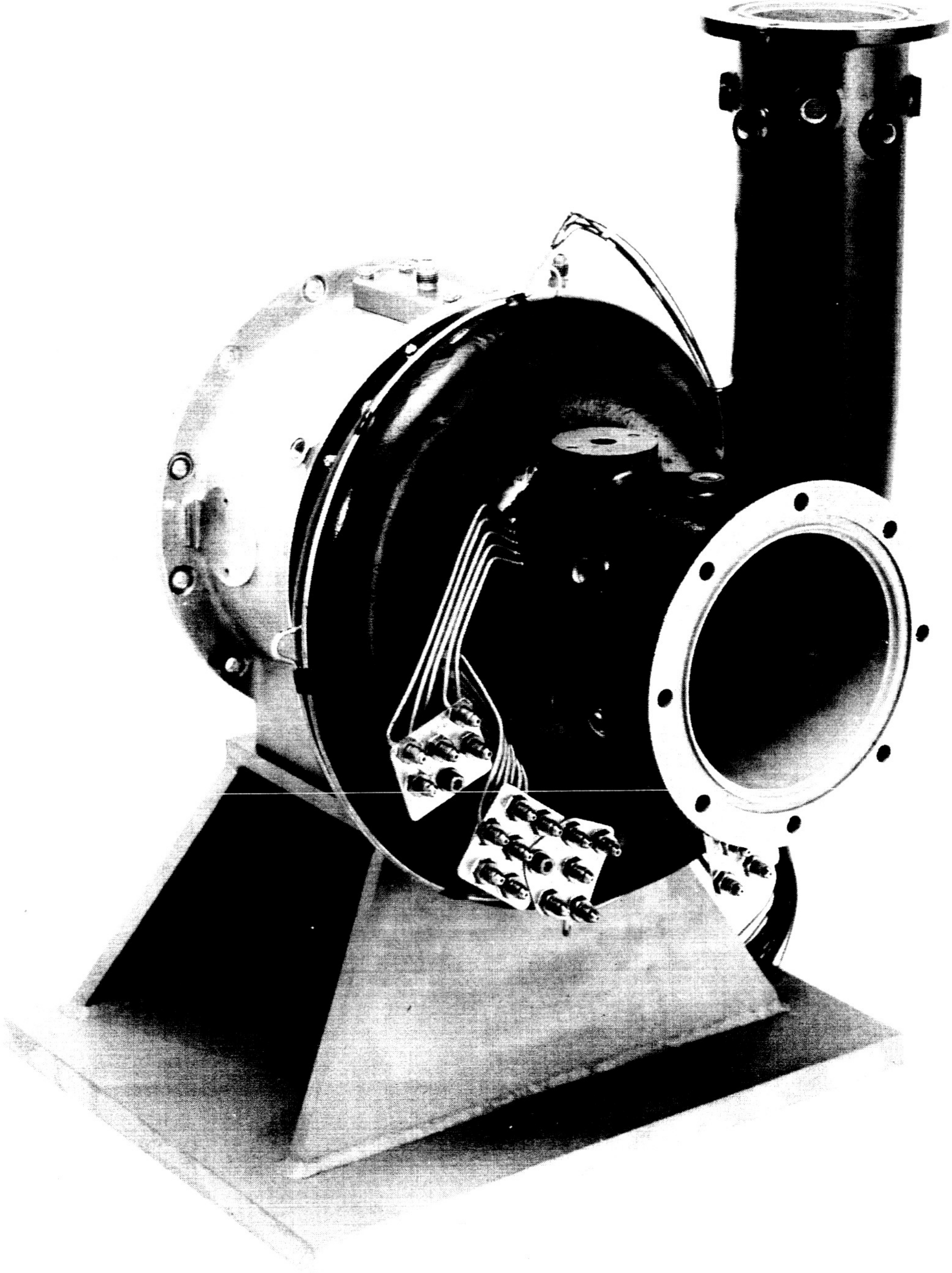
(1) Four static pressure taps in the same plane 90 degrees apart.

(2) Four total pressure taps 0.5 inch downstream of the static taps, rotated 45 degrees to the static taps and 90 degrees apart.

(e) Bearings

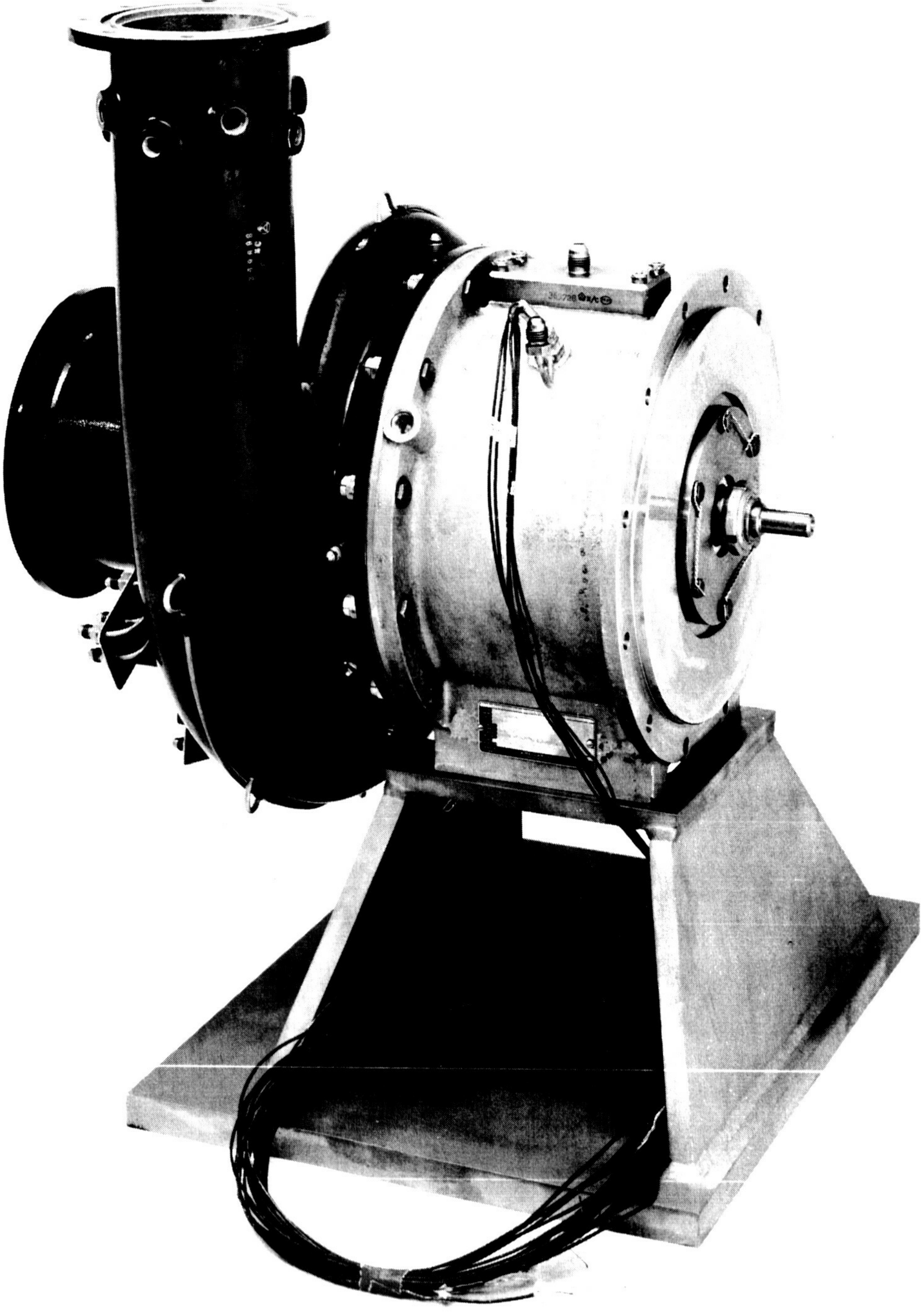
Three I.C. thermocouples on each bearing.

On the first shipping unit, Serial No. P-A, drilled and tapped bosses and the associated instrumentation plumbing was provided as shown in Figures 26, 27, and 28. For the second shipping unit, Serial No. P-B, undrilled bosses were provided.

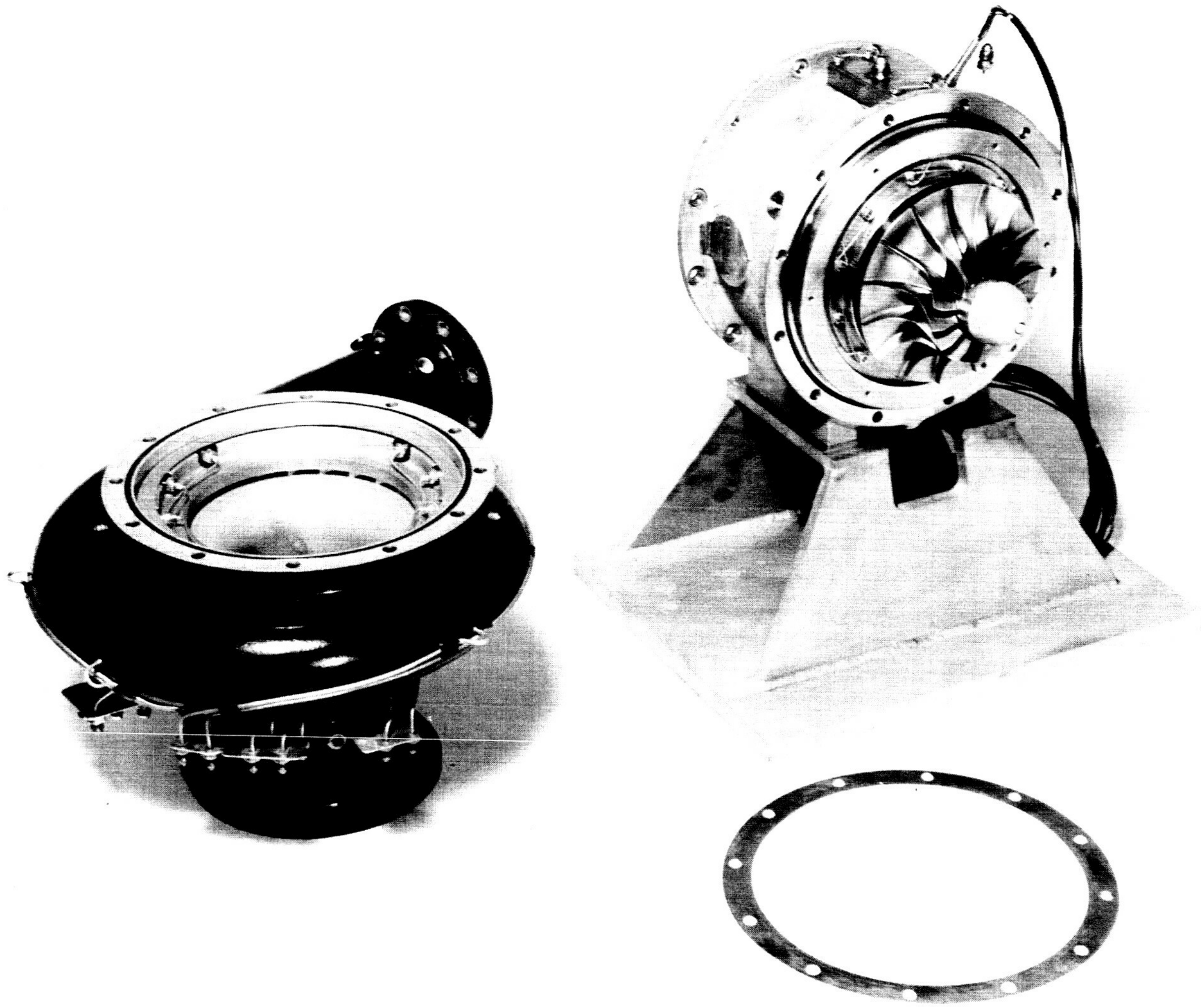


SERIAL NO. P-A
NASA COMPRESSOR RESEARCH PACKAGE

FIGURE 26



SERIAL NO. P-A
NASA COMPRESSOR RESEARCH PACKAGE
FIGURE 27



SERIAL NO. P-B
NASA COMPRESSOR RESEARCH PACKAGE

FIGURE 23

3.4.3 Inspection

Inspection of the compressor research package parts and final assembly were conducted in accordance with the quality-assurance program as outlined in AiResearch Report RC-5130-R. Figure 29 shows the Critical Parts Inspection and Serialization Record for both compressor impellers. Figures 30 and 31 show the impeller after balance inspection. Figures 32 and 33 show both sides of the Assembly Inspection and Laboratory Traveler for the two compressor research packages.

As can be seen from Figure 33, the first shipping unit was started six times and ran a total of 6.9 hours for the acceptance test. The second unit was started three times and ran for a total of 1.2 hours for its acceptance test. Following completion of the acceptance tests, the acceptance tag was completed, as shown in Figure 34.

A 793-A-5

FORM P2741-F

CRITICAL PART INSPECTION AND SERIALIZATION RECORD

Forging/Casting No.	C/L	Serial Number	O.S. GROWTH DATA	Machined Part No.	C/L
*		4X 103		*369747	N/C

Oper. Raw Matl.	Date	Insp. Stamp	Oper. Mach. Part	Date	Insp. Stamp	Control Dim/Dia	After G.R.	After O.S.	Z/M After
Dim.			Dim.			5.916800			
Ultra			Ultra/Mch			5.9785		5.9785	
HT/Stress			HT/Stress						
Zyglo/Mag			Zyglo/Mag						
Radiogr.			Pull Test						
REISNER 291160 Heat No.			Balance		BAL 6				
2nd H.T.			Overspeed	MAR 18 1964	S				
Remarks:			Green Run						
			2nd O.S.						
			R.R. No.			Part No. Changes			

MRB Disp. After	Final	Assy	R&O
USE			
RWK			
SCP			
RTV			

ITR NUMBER	
31704	E.D

*Raw Matl. Mfg. Co.

*Mach.Part Mfg. No.

COMPRESSOR RESEARCH PACKAGE
SERIAL NO. P-A

#2 N

FORM P2741-F

CRITICAL PART INSPECTION AND SERIALIZATION RECORD

Forging/Casting No.	C/L	Serial Number	O.S. GROWTH DATA	Machined Part No.	C/L
		4X 102		*369747	C

Oper. Raw Matl.	Date	Insp. Stamp	Oper. Mach. Part	Date	Insp. Stamp	Control Dim/Dia	After G.R.	After O.S.	Z/M After
Dim.			Dim.			5.9763		5.9763	
Ultra			Ultra/Mch						
HT/Stress			HT/Stress						
Zyglo/Mag			Zyglo/Mag						
Radiogr.			Pull Test						
REISNER 291160 Heat No.			Balance		BAL 6				
2nd H.T.			Overspeed	MAR 1[illegible] 1964	S				
Remarks:			Green Run						
			2nd O.S.						
			R.R. No.			Part No. Changes			

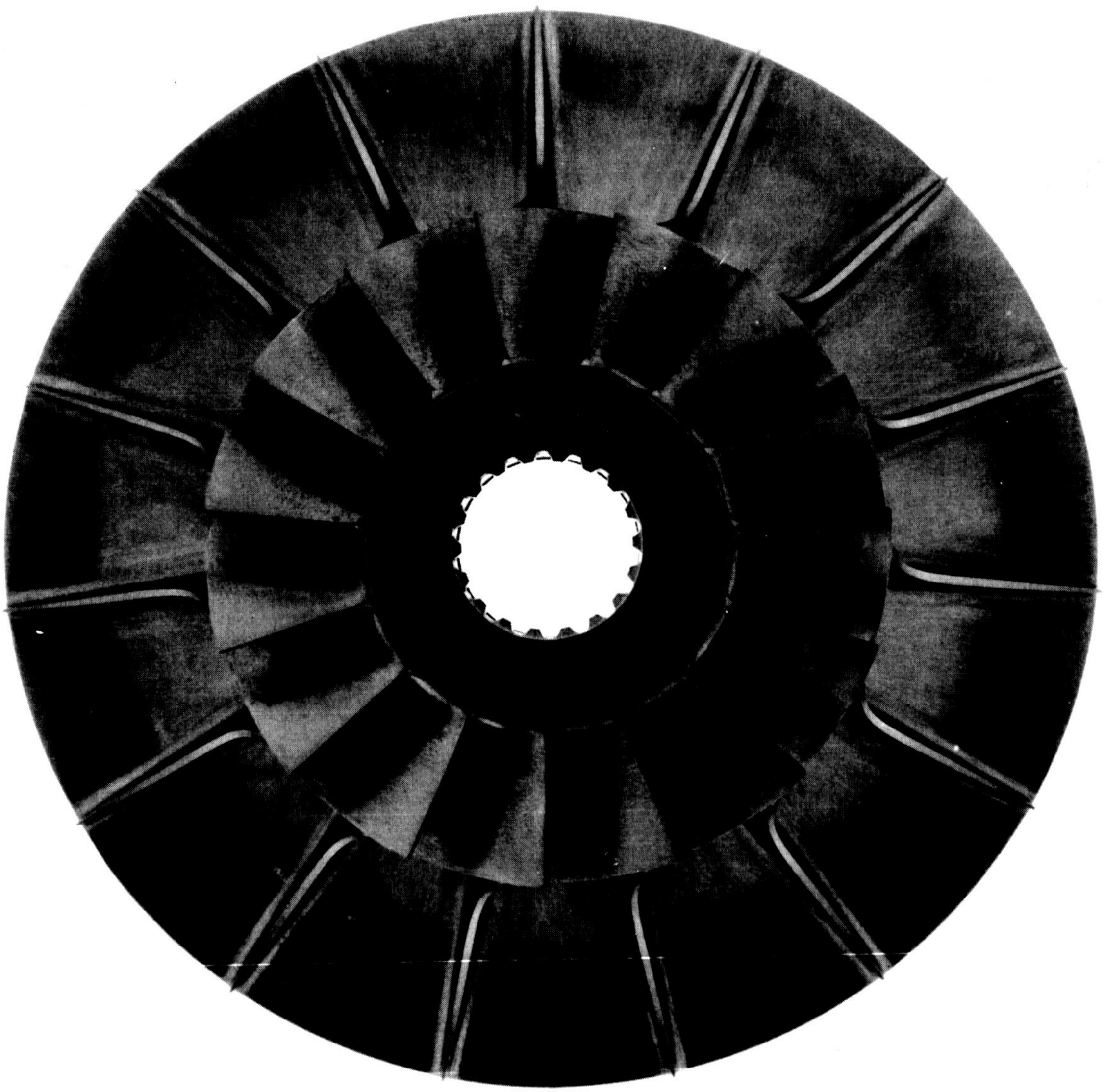
MRB Disp. After	Final	Assy	R&O
USE			
RWK			
SCP			
RTV			

ITR NUMBER	
30453 ED	

*Raw Matl. Mfg. Co.

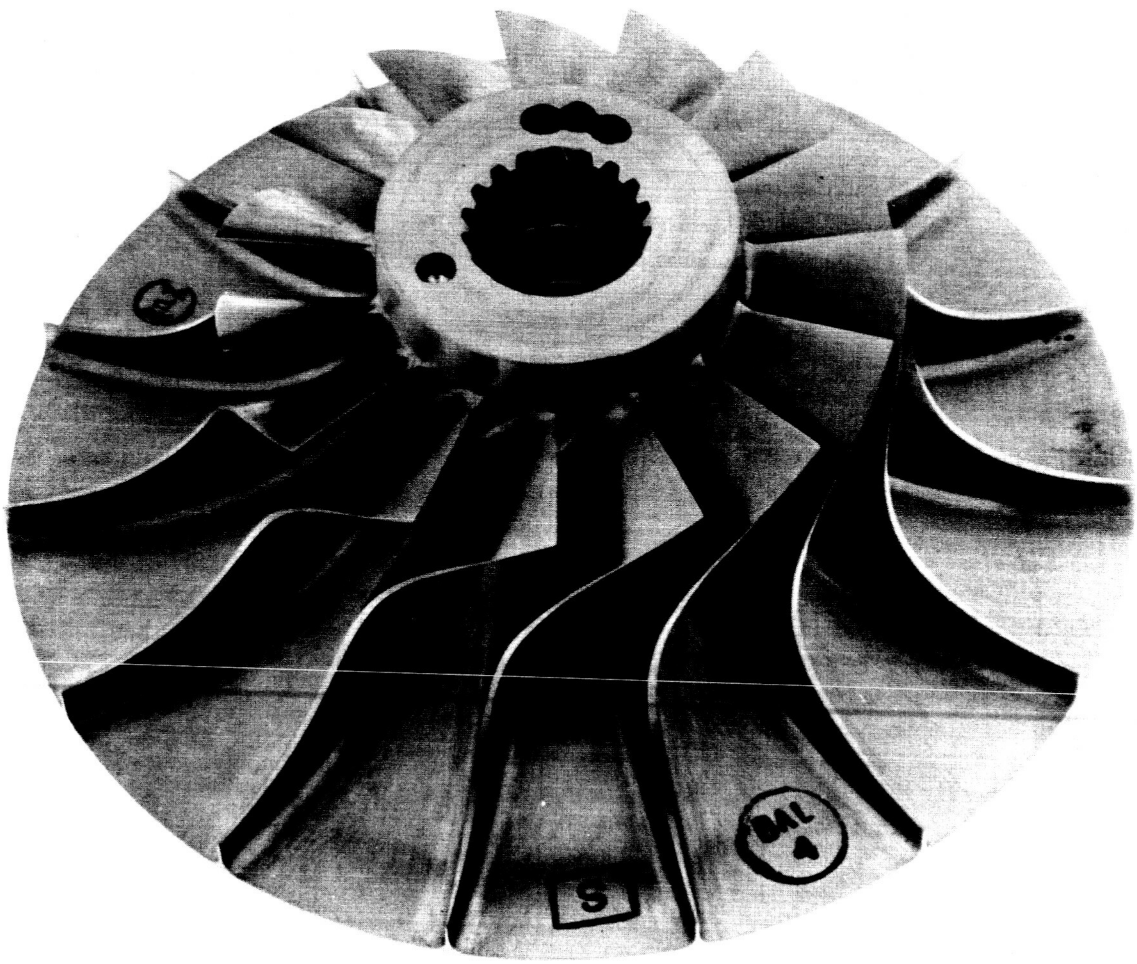
*Mach.Part Mfg. No.

COMPRESSOR RESEARCH PACKAGE
SERIAL NO. P-B
FIGURE 29



COMPRESSOR IMPELLER
NASA COMPRESSOR RESEARCH PACKAGE

FIGURE 30



COMPRESSOR IMPELLER
NASA COMPRESSOR RESEARCH PACKAGE

FIGURE 31

#1

AiResearch Manufacturing Company of Arizona — ASSEMBLY INSPECTION TRAVELER — ORIG

Outline	369739
Model	NASA
	NONE
Serial Number	P-B
Description	COMPRESSOR ASSY
Customer	NASA
Release or W.O. Number	3409-27136-13-0501
Contract	NAS3-2778

M.O.T. Number	Oper No.	Assy S.G.	Record Dimensions
Spec	7	OW	.041
"	13	OW	.043 / .354
"	17	OW	.0025 / .0185
"	23	OW	300#
"	27	OW	.010
"	33	OW	.010
"	37	OW	.166
Spec	43	O.W.	

Part Number	Serial No.
369747	4X-102

SHIPPED 5-8-64 O.Wald

Date	Assembly Signature
5-7-64	O.Wald

SERIAL NO. P-B

AiResearch Manufacturing Company of Arizona — ASSEMBLY INSPECTION TRAVELER — ORIG

Outline	369739
Model	NASA
	NONE
Serial Number	P-A
Description	COMPRESSOR ASSY
Customer	NASA
Release or W.O. Number	3409-27136-13-0501
Contract	NAS3-2778

M.O.T. Number	Oper No.	Assy S.G.	Record Dimensions
Spec	7	OW	.040
"	13	OW	.046 / .355
"	17	OW	.0032 / .0240
"	23	OW	300#
"	27	OW	.010
"	33	OW	.010
"	37	OW	.173
Spec	43	OW	

Part Number	Serial No.
369747	4X-103

SHIPPED 5-8-64 O.Wald

Date	Assembly Signature
	O.Wald

SERIAL NO. P-A

COMPRESSOR RESEARCH PACKAGE
FIGURE 32

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

Px 1372-1

AiResearch Manufacturing Company of Arizona

LABORATORY TRAVELER

S/N TRAVELER NO.

PARTS REPLACED IN LABORATORY

PART NO.	SERIAL NO.	REASON REPLACED

LABORATORY REJECTION REASONS

LAB SIG.

ENGINEERING REWORK RECOMENDATIONS

ENG. SIG.

ASSEMBLY REWORK *(LIST ALL PARTS EXCEPT AN & STD LINE PARTS)*

ASSY. SIG.

DEVIATION

CUSTOMER T. I.

	SINCE O'HAUL	TOTAL
STARTS		3
HOURS		1.2

UNIT PRESERVED	
FUEL	OIL
T I NO.	
OIL CONSUMPTION	GRAMS
WT. FLOW	
ACCEL. TIME	SECS.

SAFETY WIRED

ACCEPTED	REJECTED	DATE

LAB SIGNATURE Frank C. Bonder

SERIAL NO. P-B

Px 1372

AiResearch Manufacturing Company of Arizona

LABORATORY TRAVELER

S/N TRAVELER NO.

PARTS REPLACED IN LABORATORY

PART NO.	SERIAL NO.	REASON REPLACED

LABORATORY REJECTION REASONS

LAB SIG.

ENGINEERING REWORK RECOMENDATIONS

ENG. SIG.

ASSEMBLY REWORK *(LIST ALL PARTS EXCEPT AN & STD LINE PARTS)*

ASSY. SIG.

DEVIATION

CUSTOMER T. I.

	SINCE O'HAUL	TOTAL
STARTS		6
HOURS		6.9

UNIT PRESERVED	
FUEL	OIL
T I NO.	
OIL CONSUMPTION	GRAMS
WT. FLOW	
ACCEL. TIME	SECS.

SAFETY WIRED

ACCEPTED	REJECTED	DATE

LAB SIGNATURE Frank C. Bonder

SERIAL NO. P-A

COMPRESSOR RESEARCH PACKAGE
FIGURE 33

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

Research Manufacturing Company of Arizona

ACCEPTANCE TAG

PRODUCT NOMENCLATURE: COMPRESSOR ASSY RESEARCH, NASA

PART NO. 369730

MODEL NO. NONE

MEO'S NONE

QTY 2

INSP. STAMP

DATE 5-8-64

INSP. SIGNATURE R. Sanderson

ALLOCATION AUTHORIZED SIGNATURE

DATE

ENG. REC.—SPLIT

S. O. NO.	END ITEM SERIAL NO.	SUB-UNIT CONFIGURATION PART NO.	SERIAL NO.	MODEL NO.	MEO NO'S
27126	P-A	369747	4X-103	H. 6, 9	5. 6
	P-B	369747	4X-102	H. 1, 2	5. 3

COMPRESSOR RESEARCH PACKAGE

FIGURE 34

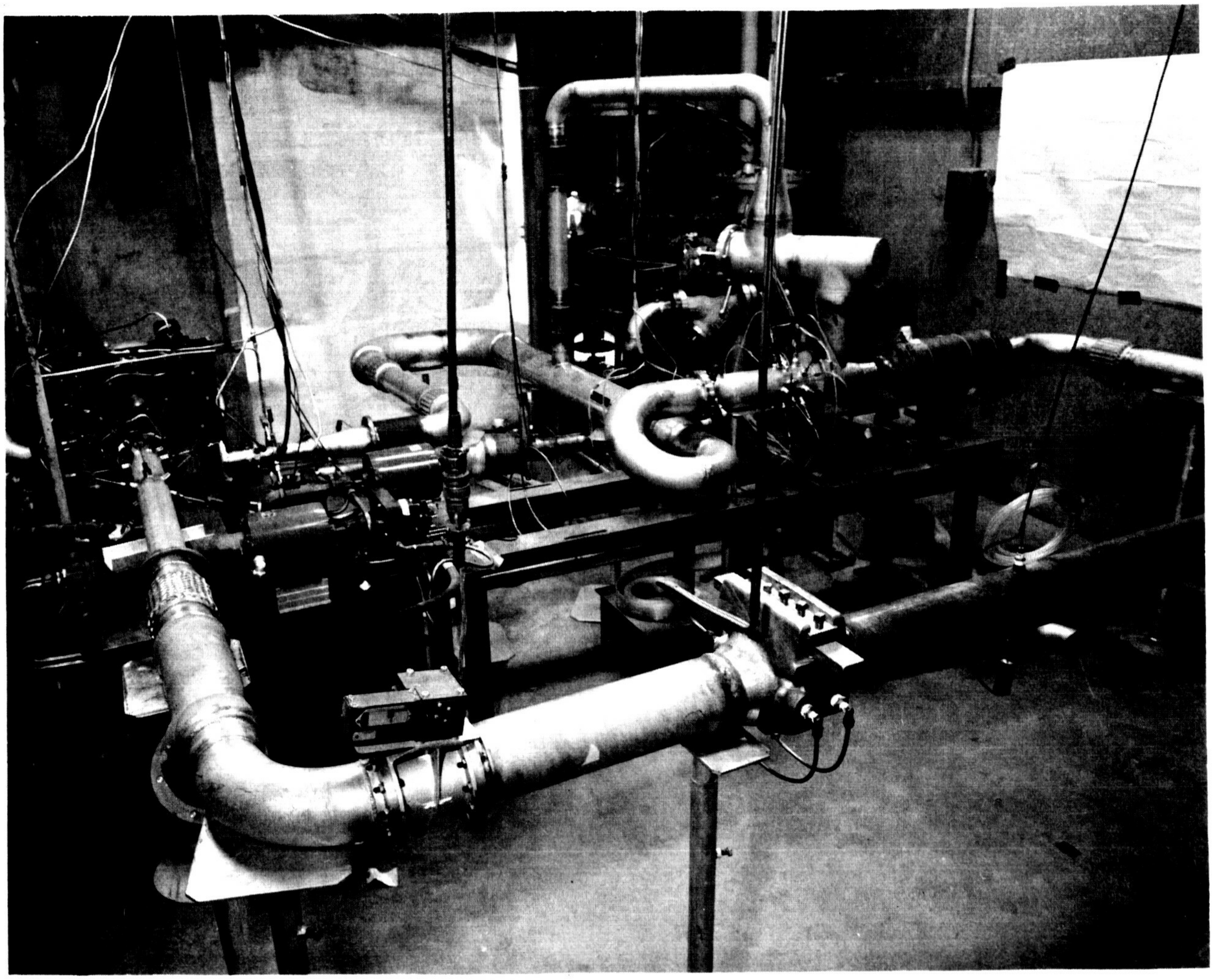
4.0 COMPRESSOR TESTING

4.1 Test Loop

The development and shipping compressor was tested in the closed loop, shown in Figure 35, with argon used as the working fluid. The loop was fabricated from stainless steel tubing of a nominal 4-inch diameter with appropriate transitions to the inlet and discharge of the compressor and other components in the loop. To reduce the system leakage, welded joints were used throughout the system with the exception of the flanged joints at the compressor and the motorized control valve. The loop consisted of the following components:

(a) Orifice measuring section
(b) Motorized valve
(c) Filter
(d) Vacuum pump
(e) Compressor
(f) Drive turbine
(g) Heat exchanger (cooler)
(h) Cooling turbine and heat exchanger
(i) Instrumentation

The filter was used as a precaution against the induction of any particle that might damage the impeller blades. The filter body was also the station for evacuation of the loop. The vacuum pump was used to purge the loop of air and to control the argon pressure level during the tests. (As the pressure ratio of the compressor was varied, the loop pressures would change, which would require the addition or removal of argon to maintain a constant compressor inlet pressure.)



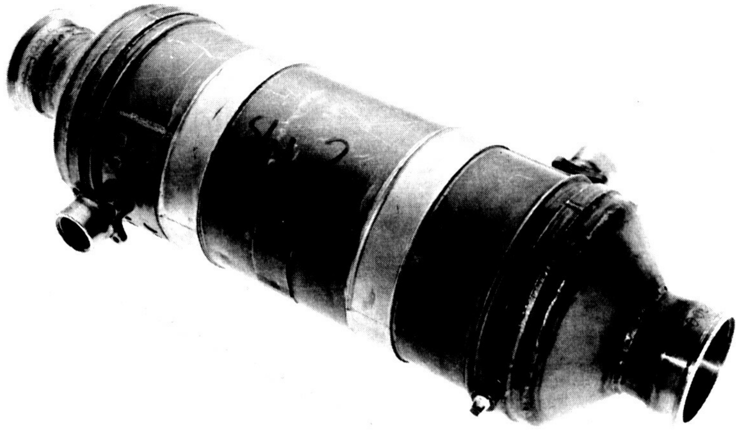
BRAYTON-CYCLE TURBOMACHINERY TEST LOOP

FIGURE 35

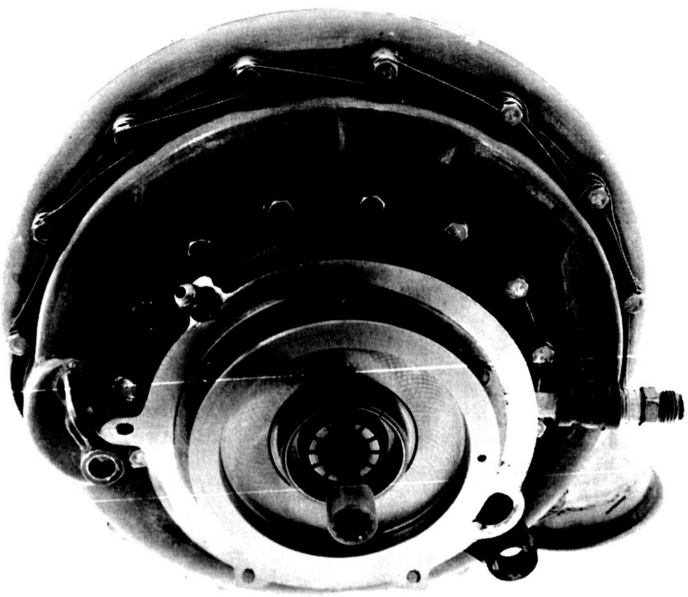
The compressor under test was installed in the loop with flanged joints used to permit easy removal for changes of the diffuser or impeller cutback. The compressor was insulated with 1 inch of foil-backed fiber glass during all testing to facilitate accurate temperature measurement. The compressor was driven through a quill shaft by an air turbine motor, shown in Figure 36. The speed of the turbine was controlled by a pneumatically controlled valve installed in the plant air system.

A water-cooled gas heat exchanger, shown in Figure 36, was used to control the compressor inlet gas temperature. Motorized valves on the water side of the heat exchanger permitted control of the compressor inlet temperature to within 1°F. At compressor flows and pressure ratios where full flow of the plant water supply would not control the loop gas temperature, chilled water from a second air-to-water heat exchanger was piped through the test loop heat exchanger. The water was chilled by air from an air-driven cooling turbine.

The basic compressor instrumentation consisted of thermocouples, static pressure taps, and total pressure probes located at the inlet and discharge ducts of the compressor. Special static pressure taps were installed in the inlet scroll to facilitate impeller cutback. The thermocouples were designed for maximum accuracy over the range of Reynolds numbers to be encountered in testing.



WATER-TO-GAS HEAT EXCHANGER



AIR TURBINE MOTOR

COMPONENTS OF BRAYTON-CYCLE TURBOMACHINERY CLOSED TEST LOOP
FIGURE 36

4.2 Development Testing

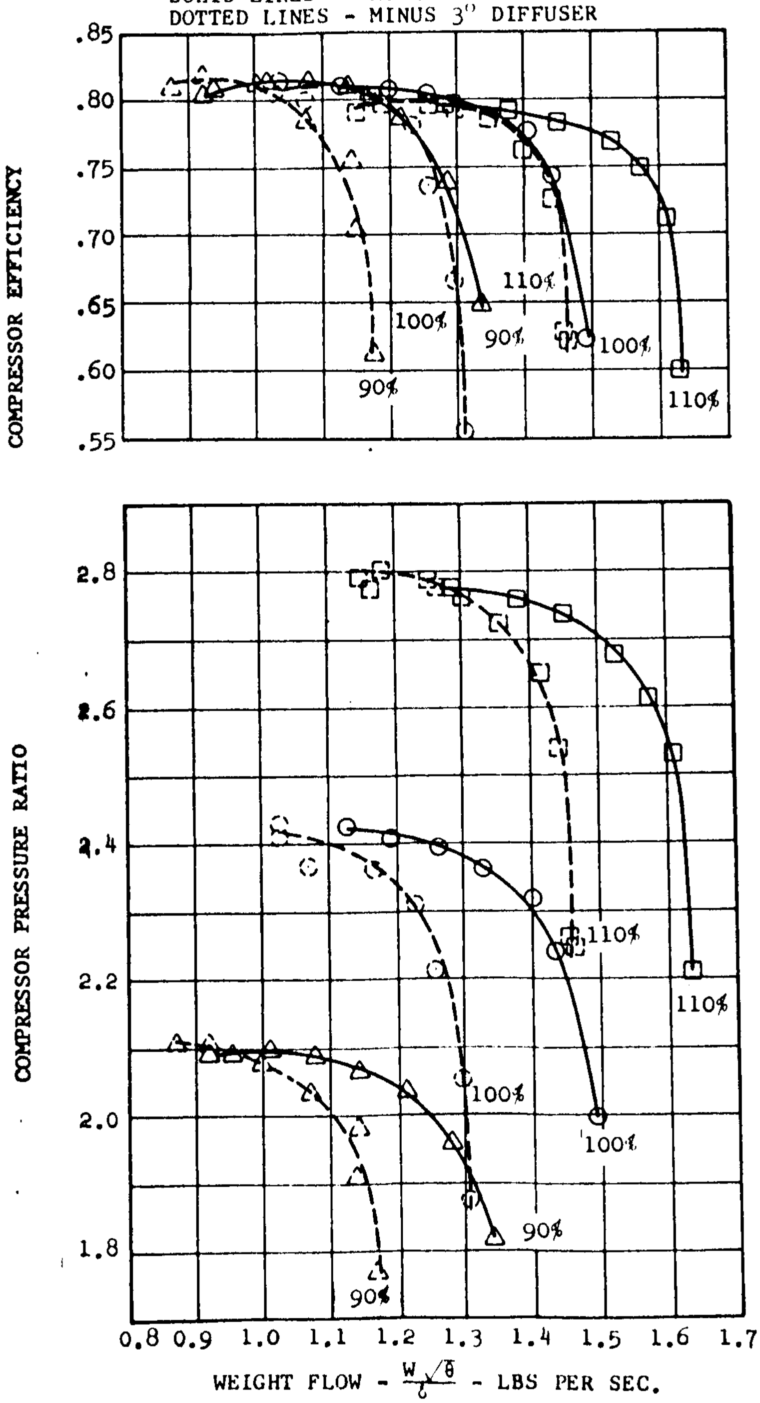
The development compressor impeller was tested with three diffusers--a nominal diffuser, a negative 3-degree diffuser, and a positive 3-degree diffuser. The compressor impeller was fabricated with an extended leading edge so that the optimum match of diffuser and impeller could be obtained. With the extended leading edge, the flow at design pressure ratio was expected to be lower than the design value. The negative 3-degree diffuser should have given the best performance with the uncut impeller.

The uncut impeller was tested with the three diffusers and the results (see Figures 37 and 38) indicate that at the design pressure ratio (2.30) and speed (38,500 rpm), the flow was about 81 percent of the design corrected flow rate (1.524) when the negative 3-degree diffuser was used. Increasing the diffuser area (using the nominal diffuser) results in a considerable increase in flow rate and a somewhat smaller additional increase in flow with the positive 3-degree diffuser. The trend shown in Figures 37 and 38 indicates that further increases in diffuser area would have a small effect, since the inducer flow limit is being approached.

In order to increase the flow, the inducer leading edge was cut back so that the blade angles were increased to the design value. The cutback wheel was tested with the nominal diffuser, and the test results showed a 5-percent deficiency in flow at the design condition. This deficiency was probably due to an under-estimation of the boundary-layer clogging at the diffuser throat. Accordingly, the positive 3-degree diffuser was tested. As shown in Figure 35, the design flow and efficiency were exceeded in this test. The efficiency at the design corrected mass flow is 0.783.

TEST FLUID - ARGON
COMPRESSOR INLET TOTAL PRESSURE - 12.0 TO 12.5 IN. Hg ABS
COMPRESSOR INLET TOTAL TEMPERATURE - 536°R

100 PERCENT $N/\sqrt{\theta}$ = 37,900 RPM
SOLID LINES - NOMINAL DIFFUSER
DOTTED LINES - MINUS 3° DIFFUSER



NASA BRAYTON CYCLE COMPRESSOR
UNCUT IMPELLER, NOMINAL AND MINUS 3° DIFFUSERS

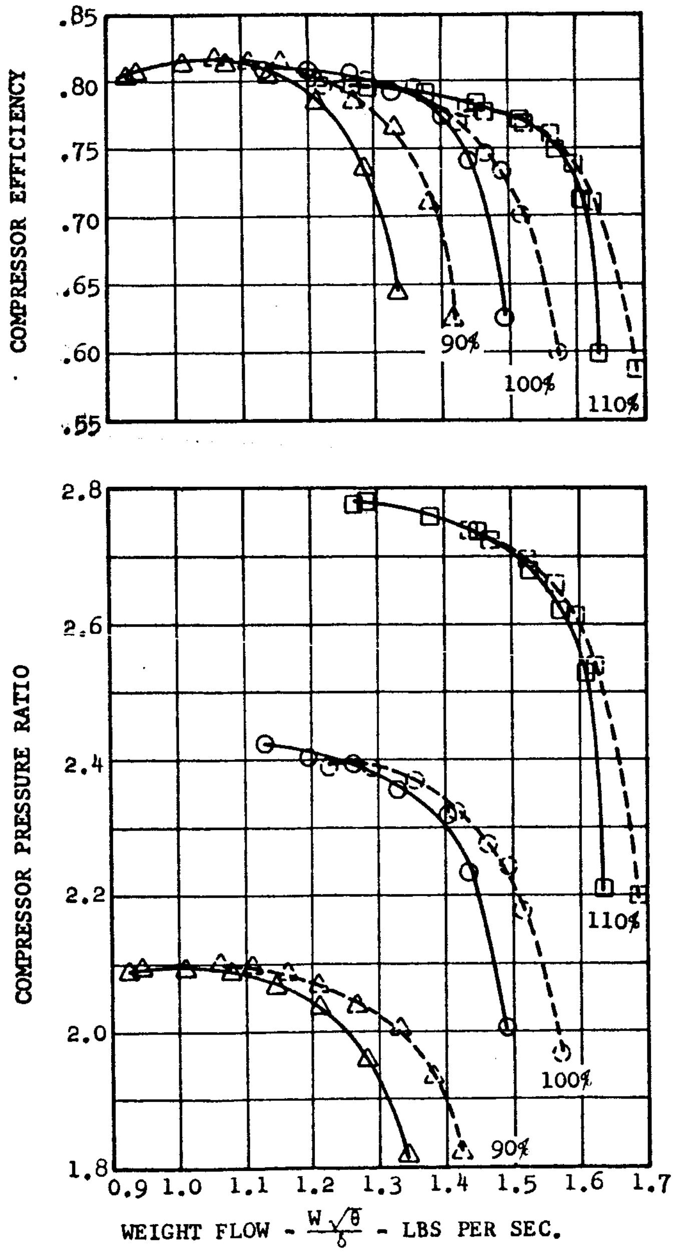
A31364-1

FIGURE 37

TEST FLUID - ARGON
COMPRESSOR INLET TOTAL PRESSURE - 12.0 TO 12.5 IN. Hg ABS
COMPRESSOR INLET TOTAL TEMPERATURE - 536°R

100 PERCENT $N/\sqrt{\theta}$ = 37,900 RPM

SOLID LINES - NOMINAL DIFFUSER
DOTTED LINES - PLUS 3° DIFFUSER



NASA BRAYTON CYCLE COMPRESSOR
UNCUT IMPELLER, NOMINAL AND PLUS 3° DIFFUSERS

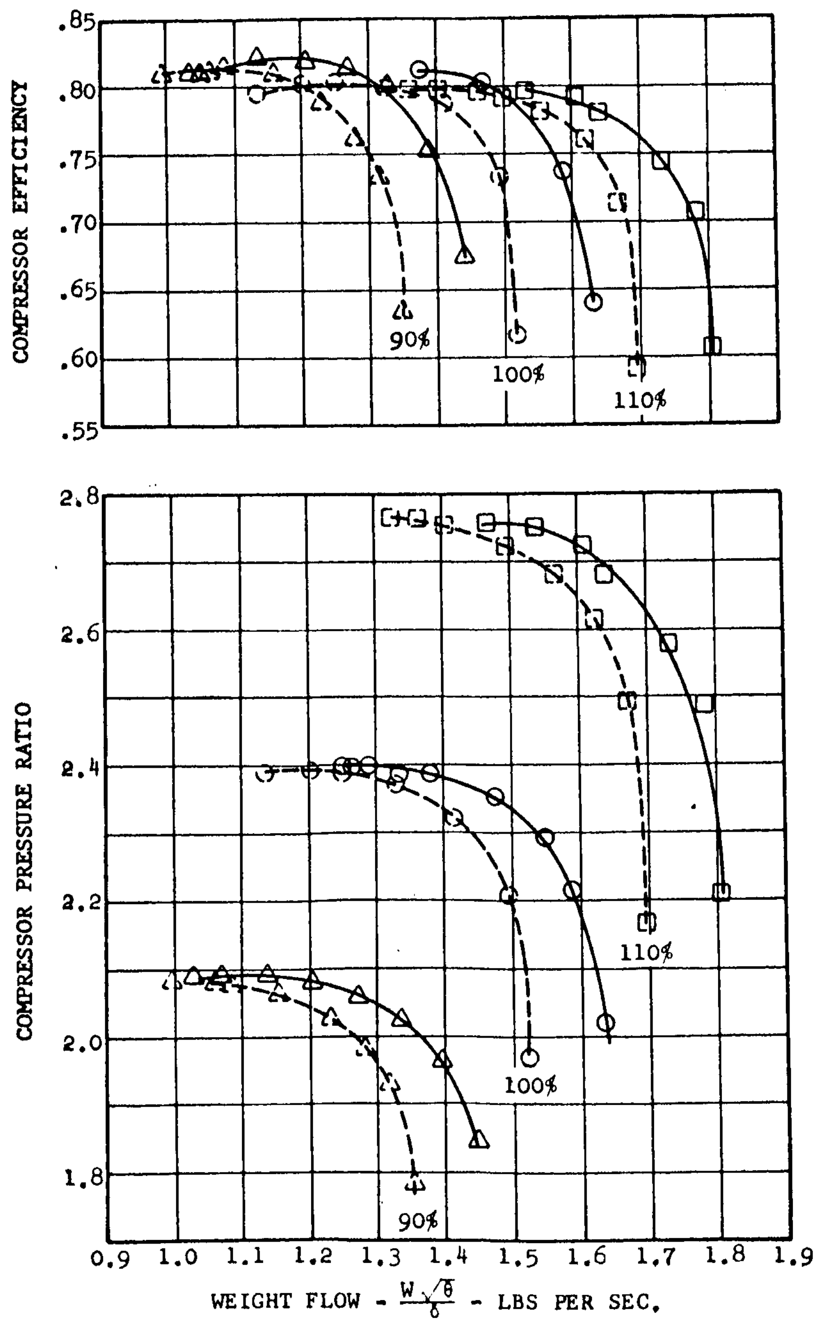
FIGURE 33

A31363-1

TEST FLUID - ARGON
COMPRESSOR INLET TOTAL PRESSURE - 12.0 TO 12.5 IN. Hg ABS
COMPRESSOR INLET TOTAL TEMPERATURE - 536°R

100 PERCENT $N/\sqrt{\theta}$ = 37,900 RPM

SOLID LINES - PLUS 3° DIFFUSER
DOTTED LINES - NOMINAL DIFFUSER



NASA BRAYTON CYCLE COMPRESSOR
CUTBACK IMPELLER, NOMINAL AND PLUS 3° DIFFUSERS

A31365-1

FIGURE 39

Since the peak efficiency at design speed is about 0.81, additional performance increase may be possible with further impeller cutback and/or larger diffuser.

4.3 Acceptance Testing

4.3.1 Testing Requirements

The acceptance testing requirements, established in NASA letter 1443, dated May 18, 1964, and signed by the contracting officer, John E. Dilley, are listed below:

(a) Instrumentation shall be added to the existing bosses in the exit scroll of the No. 1 Compressor, and the unit operated in Argon over a range of pressure ratios at speeds of 90, 100, and 110 percent of design speed. Upon completing these runs and recording the test data, the unit shall be operated at 120 percent of design speed for five (5) minutes and then shutdown.

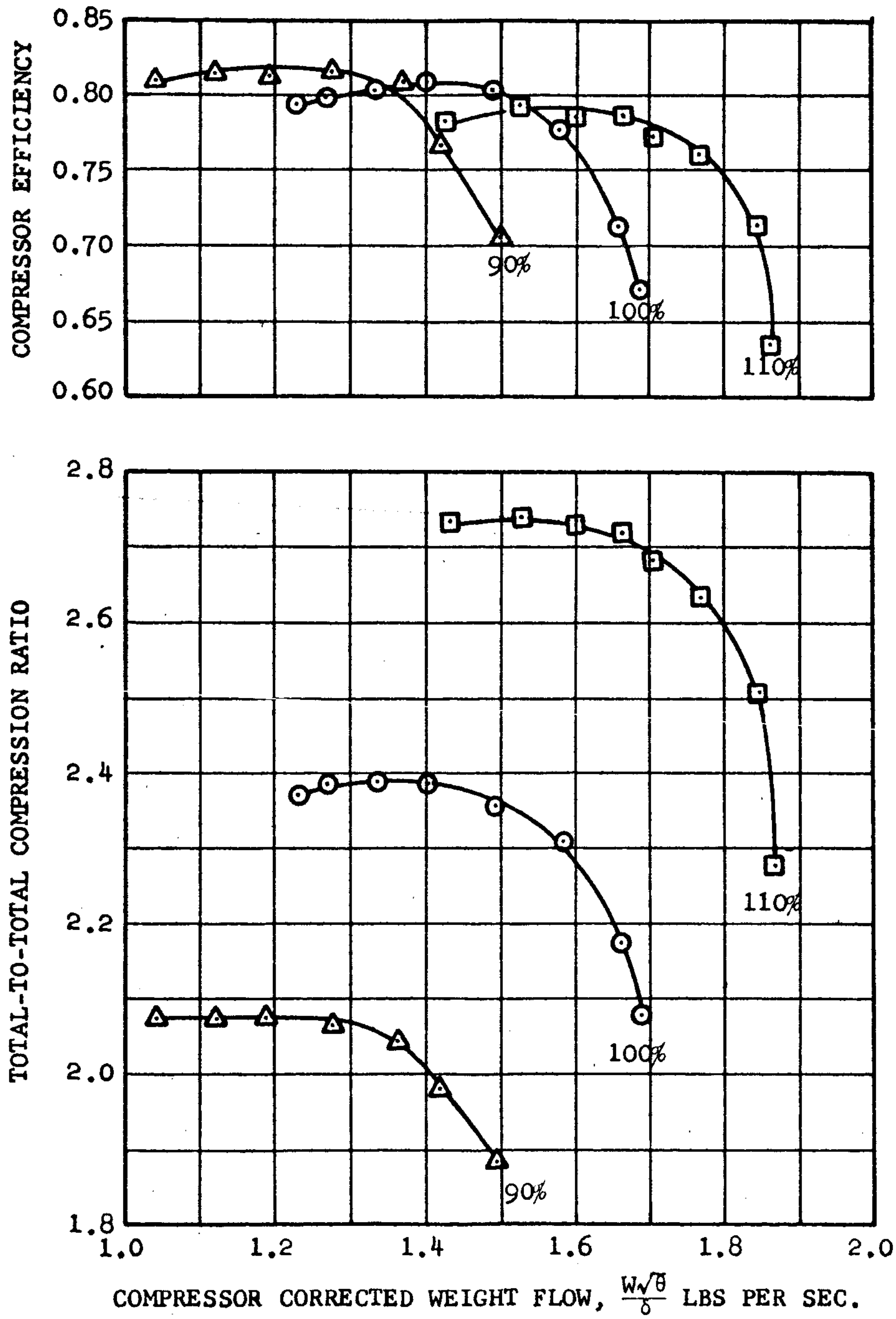
(b) The Number 2 Compressor shall be operated for a minimum of one (1) hour, and until bearing temperatures have stabilized. Operation shall be at design speed and with any convenient cold gas. Finally, the unit shall be operated at 120 percent of design speed for five (5) minutes and then shutdown.

4.3.2 Acceptance Testing

Based on the results of the development testing cutback, the impeller for the first shipping unit (Serial No. P-A) was cut back to the same configuration. The completed compressor was fully instrumented and mapped with the positive 3-degree diffuser. Figures 26 and 27 show this unit and Figure 40 shows the resulting compressor map. The second shipping unit (Figure 28) was run for a total of 1.2 hours at the design conditions. No performance map was generated since the compressor was shipped with undrilled instrumentation bosses.

Figures 41, 42, and 43 show the acceptance test logs for both units and Figures 44 and 45 show the data sheets for the acceptance tests.

TEST FLUID - ARGON
COMPRESSOR INLET TOTAL PRESSURE - 12.0 TO 12.5 IN. Hg ABS
COMPRESSOR INLET TOTAL TEMPERATURE - 536°R
100 PERCENT $N/\sqrt{\theta}$ = 37,900 RPM



6 IN. DIA COMPRESSOR TEST

A31391-1

FIGURE 40

FORM NO. P5330
500 BOOKS 2-62 AMPCO

AiResearch Manufacturing Company of Arizona — Page No. 19 of 2

QUALIFICATION TEST LOG

E.W.O. No. 3409-27136-16-0506 Date 4-23-64 Test Cell or Station No. D-107

Assembly No. ____ Model No. ____ Unit Serial No. ____

Development Engineer D- McMORROW Technician BENDER Grp. Ldr. COLLINS

Test Type ____ Test Schedule ____ Modification ____

TIME START	TIME STOP	Event	O.C.
		DAYS 4-23-64	
		CLEANED CELL.	
		FLUSHED WITH SOLVENT THE ATM-100-44 WHEEL ASSY USED TO DRIVE THE COMPRESSOR ON PREVIOUS RUNS, RE LUBRICATED SAME WITH 7808 OIL.	
		~~[illegible]~~	
		TOTAL RUN TIME 23.3	HR
		STARTS 26.0	STRS.
		5-5-64 DAYS	
		MOUNTED ONE OF THE 2 COMPRESSORS THAT ARE TO BE SHIPPED ON THE PORTABLE STAND FOR AN OPEN AIR RUN, (S/N P-13)	
		BEGAN INSTALLING SECOND COMPR. IN LOOP (S/N P-A)	
		5-5-64 DAYS	
		COMPLETED INSTALLATION OF COMP S/N (P-A) IN LOOP	
		PUMPED LOOP TO 28.5" Hg & BACK PURGED WITH ARGON 4 TIMES	
		CHANGED ARGON BOTTLES	

TOTAL TIME ON DEVELOPMENT COMPRESSOR

SUMMARY: Total Running Time ____ hrs. ____ min. Ref. Data Page ____
Total Manual Starts ____
Total Automatic Starts ____ Engineering ____

ORIGINAL

FIGURE 41

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

FORM NO. P5330
500 BOOKS 2-62 AMPCO

AiResearch Manufacturing Company of Arizona

QUALIFICATION TEST LOG

E.W.O. No. 3409-27136-16-0505 | Date 5-6-64 | Test Cell or Station No. D-107

Assembly No. | Model No. | Unit Serial No.

Development Engineer D McMURROW | Technician BENDIER | Grp. Ldr. COLLINS

Test Type | Test Schedule | Modification

TIME START	TIME STOP	Event	O.C.
1420		SET SPD @ 25,000 RPM FOR SHORT BREAK-IN PERIOD	
	1430	DN. TO REPLACE COMP. & LEAD	
1512		SET SPD @ 90% (34,650 RPM) FOUND SURGE @ 8.2 "H_2O ΔP (P_1 25.4 "HGA.) TOOK DATA COL. AA-BB PAGE 12	
	1605	DN. = END OF SHIFT	
		5-6-64 DAYS	
0830		SET SPD @ (34650 RPM) TOOK DATA COL CC-GG PAGE 12	
	1005	DN. TO PUMP & PURGE BETWEEN SPD. LINES	
1015		SET SPD. @ 100% (38500 RPM) FOUND SURGE @ 10.3 "H_2O ΔP TOOK DATA PTS HH-KK PAGE 12	
	1155	DN FOR LUNCH	
1245		SET SPD. @ (38500 RPM) TOOK DATA LINE LL = 00 PAGE 12	
	1320	DN. TO PUMP DOWN SYSTEM & PURGE WITH ARGON	
1345		SET SPD @ (42350 RPM) FOUND SURGE @ 12.3 "H_2O ΔP TOOK DATA COL. AA-HH PAGE 13 SET SPD @ 100% (46200 RPM) FOR 5 MIN RUN TOOK DATA COL II-JJ PAGE 13	
	1545	DN	

START ACCEPTANCE TEST ON UNIT SERIAL NO. P-A

END ACCEPTANCE TEST ON UNIT SERIAL NO. P-A

SUMMARY: Total Running Time ____ hrs. ____ min. Ref. Data Page ____
Total Manual Starts ____
Total Automatic Starts ____ Engineering ____

ORIGINAL

FIGURE 42

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

FORM NO. P5330
500 BOOKS 2-62 AMPCO

AiResearch Manufacturing Company of Arizona — Page No. 2 of 2

QUALIFICATION TEST LOG

E.W.O. No. 3409-27136-16-0505 | Date 5-6-64 | Test Cell or Station No. D-107

Assembly No. ____ | Model No. ____ | Unit Serial No. ____

Development Engineer D McKENROW | Technician BENDER | Grp. Ldr. COLLINS

Test Type ____ | Test Schedule ____ | Modification ____

TIME START	TIME STOP	Event	O.C.
		DAYS INTO SWING	
		HOOKED UP COMP. (S/N P-B) &	
		READIED FOR RUN	
1725		START & SET SPD. @ 20000 RPM	
		FOUND VIB. CRITICAL @ 22,000 RPM	
		SIDE .1 MILS	
		BOTTOM .08 MILS	
	1735	DN. TO READJUST OIL &	
		INSTALL PRESSURIZATION LINES TO	
		COMPR. BEARING HOUSING.	
1745		START & SET SPD @	
		100 % (38400 RPM)	
		1810 BEGIN 30 MIN. QUAL. RUN	
	1840	DN. TO CLEAN SCREEN ON COMPR.	
		INLET.	
1845		START	
		1850 BEGIN	
	1859	1859 END	
		100% DATA = COLL AA = GG PAGE	14
		120% DATA = COLL HH = JJ PAGE	14
		5-7-64 DAYS	
		REMOVED COMPRESSORS S/N P-A & P-B	
		FROM CELL & DELIVERED	
		TO DEV. ASSY.	
		CLEANED CELL.	

START ACCEPTANC
TEST ON UNIT
SERIAL NO. P-B

END ACCEPTANCE
TEST ON UNIT
SERIAL NO. P-B

SUMMARY: Total Running Time ____ hrs. ____ min. Ref. Data Page ____
Total Manual Starts ____
Total Automatic Starts ____ Engineering ____

ORIGINAL

FIGURE 43

		90%							100%								
		1537	1400	0902	0930												
DATE & TIME 5-5-64		AA	BB	CC	DD	EE	FF	GG	HH	II	JJ	KK	LL	MM	NN	OO	PP
BAROMETER	HGA	28.65	28.65	28.665	28.66	28.66	28.66	28.66	28.65	28.66	28.64	28.64	28.61	28.60	28.60	28.60	
* LOOP ORIFICE P1	HG	-13.5	-10.8	-.01	-8.2	-7.5	-7.0	-6.6	-12.6	-3.3	-10.6	-7.6	-5.75	-4.8	-4.2	-3.7	
T1	°F	76	76	76	76	77	76	76	76	76	77	77	77	76	76	76	
Δp	H2O	28.7	21.3	17.35	14.4	12.05	10.4	8.55	35.9	10.75	29.95	22.15	17.9	14.9	13.0	11.5	
WEIGHT FLOW	#/S																
COMP. INLET TEMP. #1	°F	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	
2	°F	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	
3	°F	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	
4	°F	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	
5	°F	76	76	76	76	76	76	76	76	76	76	76	76	76	755	76	
6	°F	76	76	76	76	76	76	76	76	76	76	76	76	76	75	76	
COMP. DISC. TEMP. #1	°F	296	297	299	301	300	300	303	348	355	350	351	351	352	354	356	
2	°F	297	297	297	300	300	300	302	349	355	352	350	350	353	354	356	
3	°F	297	299	298	299	300	299	300	348	354	352	351	350	352	354	355	
4	°F	295	297	298	299	300	299	301	347	355	350	351	350	352	354	355	
5	°F	296	298	298	300	301	301	303	348	357	352	352	352	354	355	356	
6	°F	296	298	298	300	301	300	303	347	358	350	352	350	354	355	356	
SPEED = (RPM = EPUT×2)	RPM	17319	17328	17326	17345	17333	17310	17331	19255	19249	19244	19242	19253	19235	19246	19237	
VIBRATION #1 (BOTTOM)	MILS	.02	.02	.025	.02	.02	.02	.02	.03	.03	.03	.03	.02	.03	.03	.03	
#2 (SIDE)	MILS	.04	.03	.04	.03	.04	.04	.03	.04	.03	.04	.04	.04	.04	.03	.04	
OIL INLET TEMP.	°F	92	87	93	87	87	87	87	88	91	91	91	96	87	88	88	
OIL DISC. TEMP	°F	74	72	75	65	65	65	64	84	66	70	70	100	72	69	67	
32° REFERENCE	°F	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	
COMP INLET Δp STATIC/TOTAL	H2O	1.8	1.4	1.4	1.25	1.1	0.8	0.7	2.35	1.1	2.15	1.95	1.7	1.6	1.25	1.0	
COMP BEARING TEMP #1	°F	128	126	128	125	125	125	125	130	132	133	133	130	130	131	131	
2	°F	131	128	130	126	127	127	127	131	134	136	135	131	132	134	134	
3	°F	130	127	130	127	126	126	127	130	139	134	134	131	132	133	135	
4	°F	148	153	142	147	146	146	146	146	156	157	157	150	158	159	160	
5	°F	135	132	135	132	131	130	131	137	140	140	140	136	138	138	138	
6	°F	135	132	135	132	131	130	130	137	139	139	139	135	138	138	138	
COMP INLET PRESS "HG. ABS (AVG)		12.276	12.29	12.17	12.19	12.18	12.19	12.09	12.41	12.258	12.365	12.25	12.20	12.17	12.155	12.16	
LOOP ORIFICE SIZE 4.0×2.75																	
P1 AT SURGE	HGA	25.4							29.35								

* DENOTES COMPOUND GAGE

ALTITUDE EQUIPMENT DIVISION
CALCULATED
RECORDED
DRAWN
CHECKED
APPROVED

NASA COMPRESSOR S/N P-A
CLOSED ARGON RUN
2ND UNIT
1ST CUTBACK

AiResearch Manufacturing Company of Arizona

12

TANNER
BENDER

		110%								120%	
DATE & TIME 5-6-64		A-A	B-B	C-C	D-D	E-E	F-F	G-G	H-H	I-I	J-J
BAROMETER	"HgA	28.58	28.595	28.57	28.57	28.57	28.56	28.55	28.55		28.55
* LOOP ORIFICE P1	Hg	-12.1	-7.3	-4.3	-1.8	-0.4	-1.25	-2.9	0		-6.5
T1	°F	78	77	76.5	76	76	77.5	77.5	77		78
Δp	H2O	42.05	30.15	23.95	19.0	14.95	16.85	21.0	12.7		34.8
WEIGHT FLOW	#/S										
COMP INLET TEMP #1	°F	76	76	76	76	76	76.5	76	76		76
2	°F	77	76	76	76	76	76.5	76.5	76		77
3	°F	76.5	76	76	76	76	76.5	76.5	76		76
4	°F	76.5	76	76	76	76	76.5	76.5	76		77
5	°F	77	76	76	76	76	77	76.5	76		77
6	°F	76.5	76	76	76	76	76.5	76.5	76		77
COMP. DISC. TEMP #1	°F	408	410	411	412	414	414	413	417		473
2	°F	409	406	410	412	414	414	412	417		472
3	°F	408	410	409	411	413	414	411	416		474
4	°F	407	410	410	412	413	414	411	416		474
5	°F	408	411	413	414	415	416	414	417		474
6	°F	407	410	410	413	415	416	413	417		472
SPEED (RPM = EPUT×2)	RPM	21,180	21,190	21,190	21176	21176	21171	21160	21172	23070	23087
VIBRATION #1 BOTTOM	MILS	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
#2 SIDE	MILS	.03	.035	.04	.03	.04	.03	.03	.03	.03	.04
OIL INLET TEMP.	°F	90	91	91	92	91	92	92	92	92	94
OIL OUTLET TEMP.	°F	127	126	130	131	131	118	117	122	120	126
32° REFERENCE	°F	32	32	32	32	32	32	32	32	32	32
COMP. INLET Δp STATIC/TOTAL	H2O	2.85		2.4	1.9	1.6	1.75	2.3	1.3		3.15
COMP BEARING TEMP #1	°F	149	140	139	139	139	139	140	140	146	146
2	°F	141	141	141	142	142	142	142	143	145	150
3	°F	140	141	140	141	140	141	142	142	148	148
4	°F	172	174	174	175	177	175	176	177	192	195
5	°F	146	146	146	146	147	147	147	147	153	154
6	°F	145	145	145	145	145	145	146	146	153	154
COMP INLET PRESS "Hg. ABS(AVG)		12.22	12.205	12.23	12.23	12.205	12.155	12.266	12.13		12.26
LOOP ORIFICE SIZE (4.0×2.75)											
P1 AT SURGE	HgA	33.73									

* DENOTES COMPOUND GAGE

ALTITUDE EQUIPMENT DIVISION
CALCULATED
RECORDED
DRAWN
CHECKED
APPROVED

NASA COMPRESSOR S/N (P-A)
CLOSED ARGON RUN
2ND UNIT
1ST CUTBACK

AiResearch Manufacturing Company of Arizona

13

TANNER
BENDER

ACCEPTANCE TEST DATA SHEETS

FIGURE 44

			100%						120%		
		AA	BB	CC	DD	EE	FF	GG	HH	II	JJ
DATE / TIME		1729	1810	1820	1825	1830	1835	1840	1850	1855	1859
SPEED (RPM = EPUT X2)	EPUT	10000	19240	19240	19249	19255	19260	19265	23195	23158	23151
VIBRATION (BOTTOM)	MILS	.01	.03	.03	.03	.03	.03	.03	.035	.03	.035
" (SIDE)	MILS	.02	.03	.035	.035	.04	.035	.035	.04	.035	.035
OIL INLET TEMP	°F	–	85	89	90	92	93	95	95	98	100
OIL DISC TEMP	°F	–	–	–	–	–	–	–	–	–	–
32°F REF.	°F	32	32	32	32	32	32	32	32	32	32
COMP BEARINGS #1 V	°F	112	148	154	154	154	154	158	172	191	240
TURBINE END 2 Y	°F	120	198	205	206	208	208	210	218	236	241
3 W	°F	120	198	205	206	208	208	210	218	236	241
4 X	°F	120	194	202	203	203	204	205	213	232	237
COMP. END 5 Y	°F	120	195	202	203	204	205	207	213	232	237
6 Z	°F	120	195	202	203	204	205	207	213	232	238

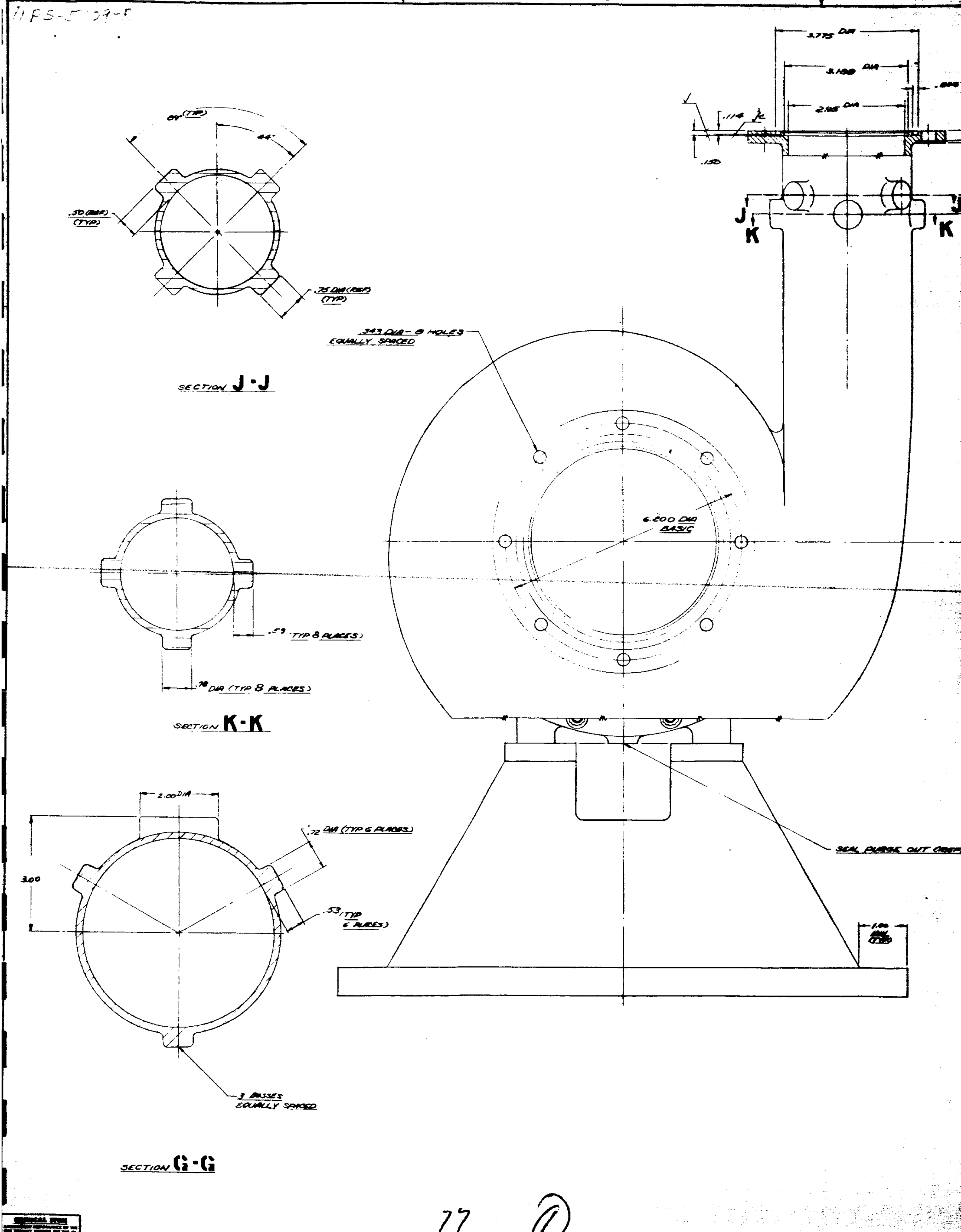
ALTITUDE EQUIPMENT DIVISION			
CALCULATED			NASA COMPRESSOR (P-B)
RECORDED			OPEN AIR RUN
DRAWN			2ND UNIT NO CUT BACK
CHECKED			AiResearch Manufacturing Company of Arizona
APPROVED			

14

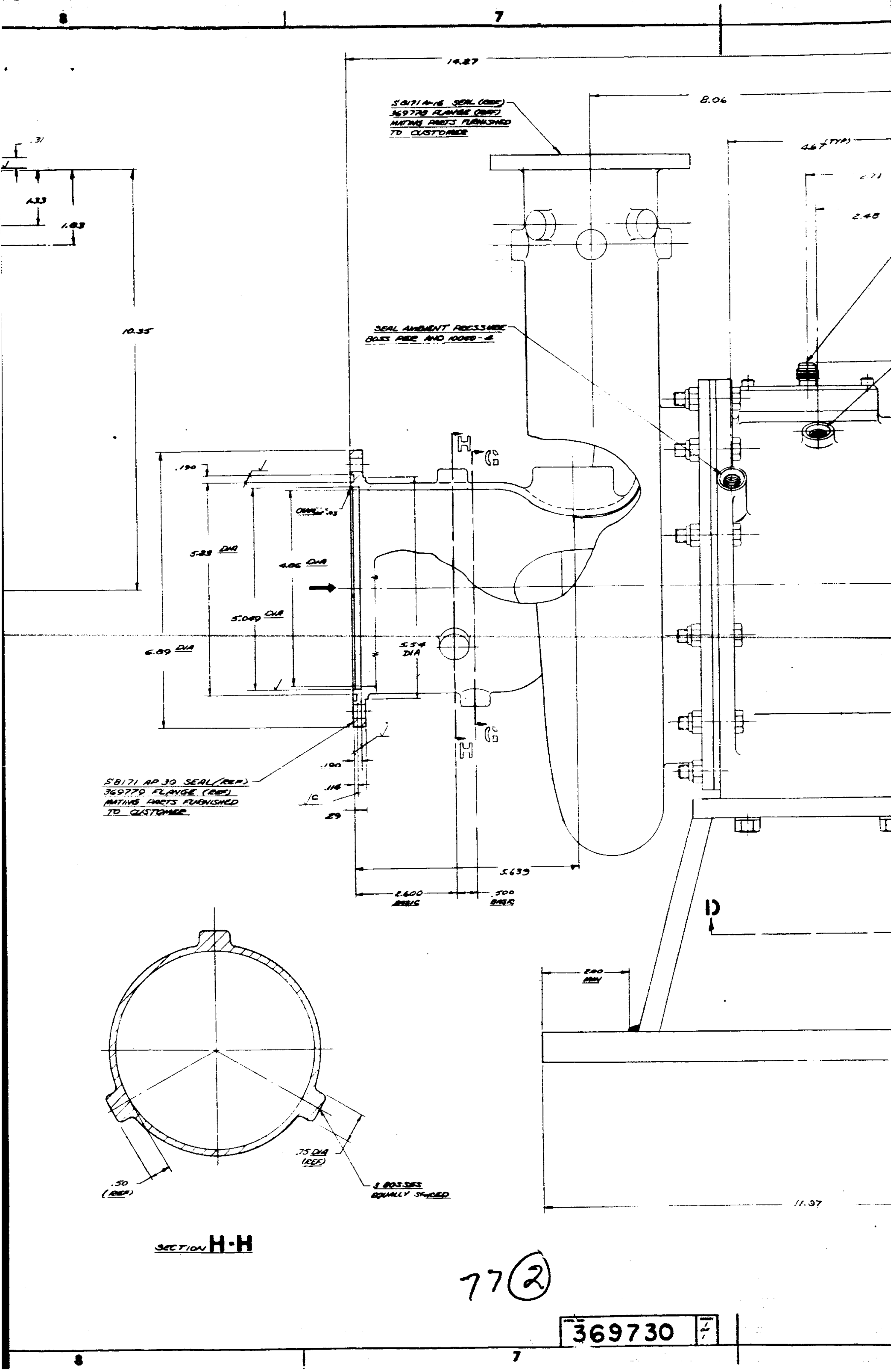
TANNER B
BANIZAR F

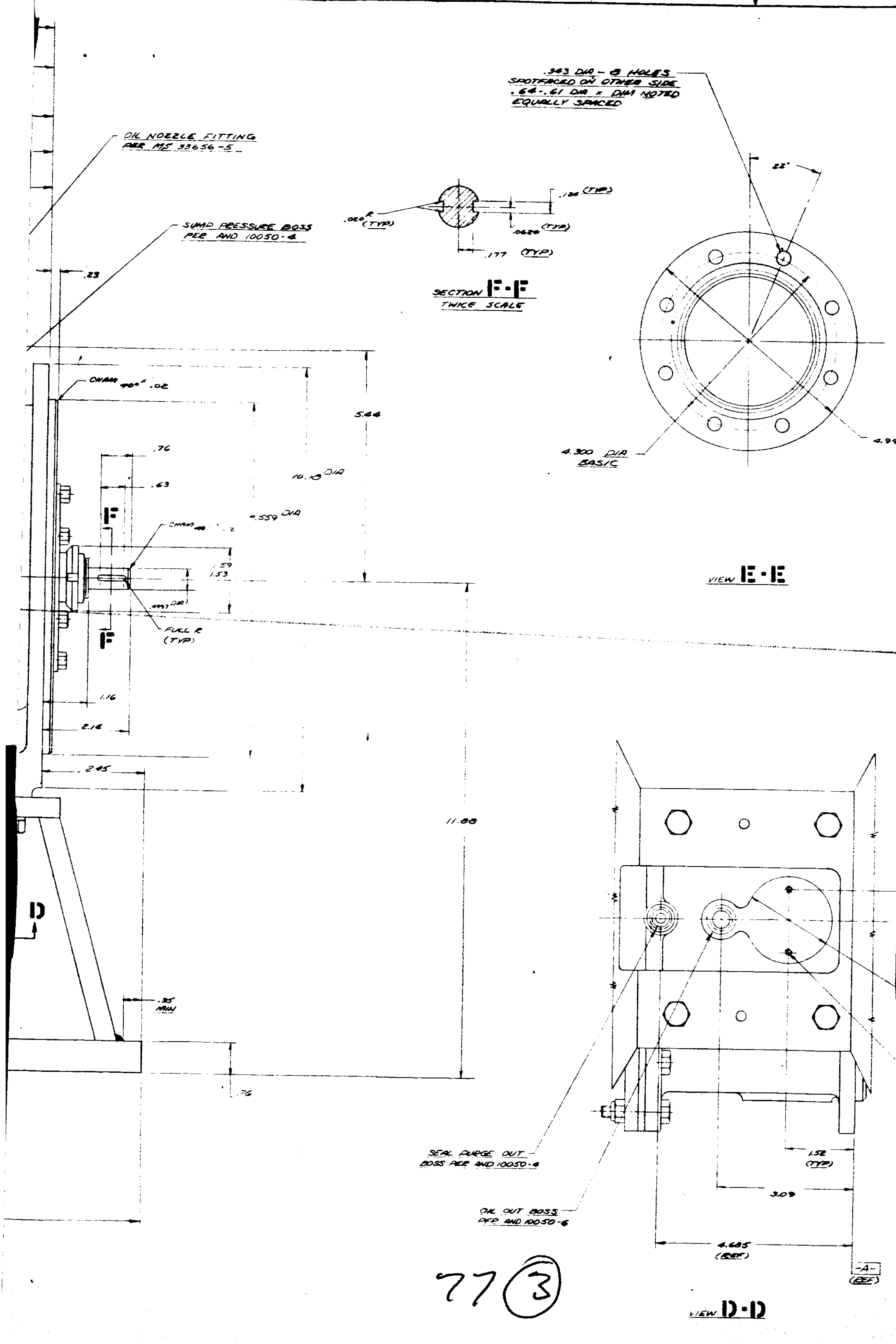
ACCEPTANCE TEST DATA SHEET

FIGURE 45


10
9
3.775 DIA
3.188 DIA
2.95 DIA
.114
.150
J
K
J
K
.50 (REF) (TYP)
.75 DIA (REF) (TYP)
44°
.343 DIA - 8 HOLES EQUALLY SPACED
SECTION J-J
6.200 DIA BASIC
.53 (TYP 8 PLACES)
.78 DIA (TYP 8 PLACES)
SECTION K-K
SEAL PURGE OUT
2.00 DIA
.72 DIA (TYP 6 PLACES)
3.00
.53 (TYP 6 PLACES)
3 BOSSES EQUALLY SPACED
SECTION G-G

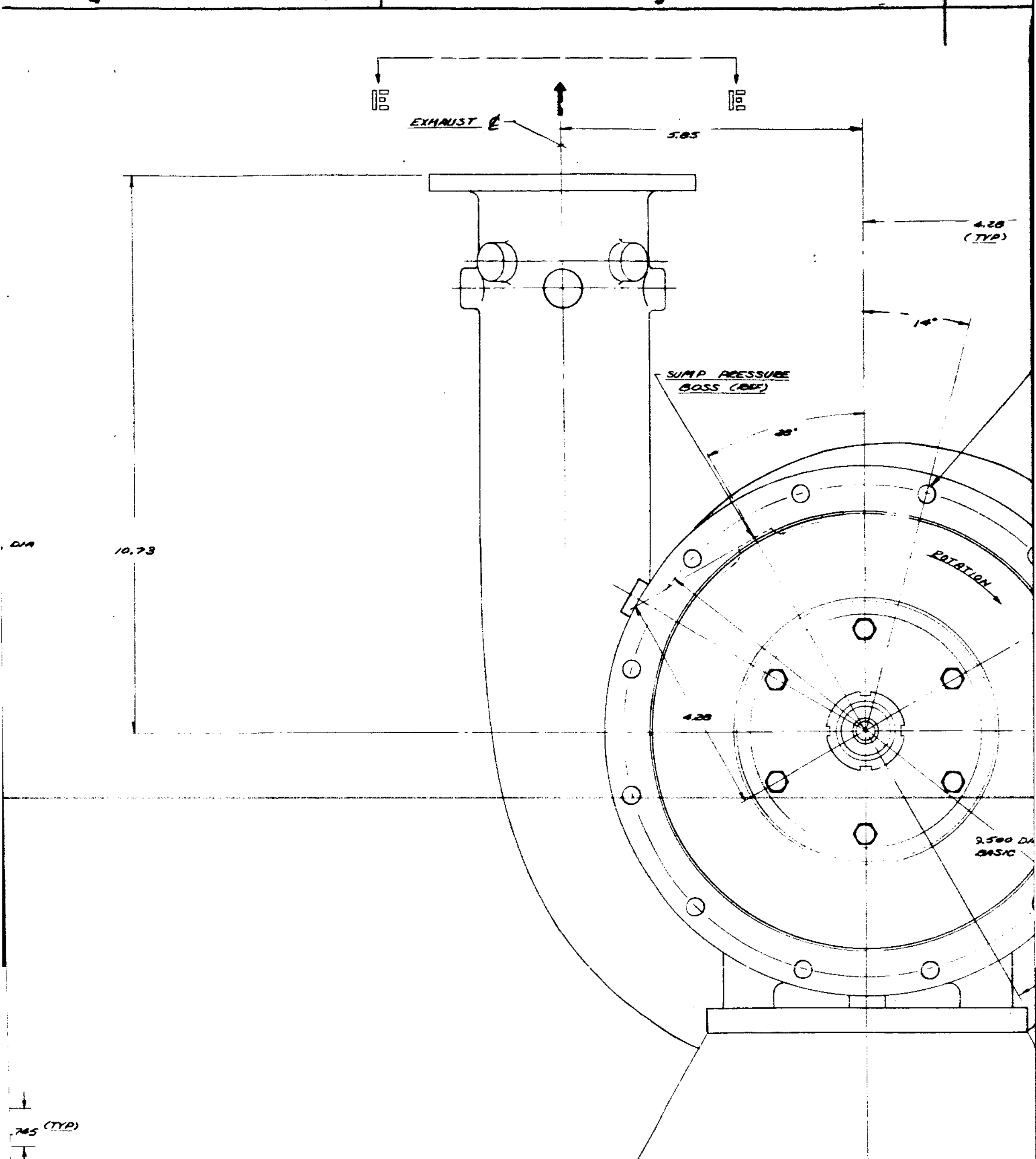
77 (1)


8
7
14.27
8.06
SB171 AN-16 SEAL (REF)
369779 FLANGE (REF)
MATING PARTS FURNISHED
TO CUSTOMER
4.67 (TYP)
2.71
2.48
.31
.33
1.83
10.35
SEAL AMBIENT PRESSURE
BOSS PER AND 10050-4
H
.190
5.23 DIA
4.06 DIA
5.069 DIA
6.89 DIA
5.54 DIA
SB171 AP 30 SEAL (REF)
369779 FLANGE (REF)
MATING PARTS FURNISHED
TO CUSTOMER
.190
.116
.29
5.639
2.600 BASIC
.500 BASIC
D
2.00 MIN
.75 DIA (REF)
.50 (REF)
3 BOSSES
EQUALLY SPACED
11.97
SECTION H·H
77 (2)
369730
8
7



.343 DIA - 8 HOLES
SPOTFACED ON OTHER SIDE
.64-.61 DIA x DIM NOTED
EQUALLY SPACED
OIL NOZZLE FITTING
PER MS 33656-5
SUMP PRESSURE BOSS
PER AND 10050-4
22°
.020 R (TYP)
.124 (TYP)
.0620 (TYP)
.177 (TYP)
SECTION F-F
TWICE SCALE
4.300 DIA BASIC
VIEW E-E
CHAM 45° x .02
5.44
10.13 DIA
4.559 DIA
.76
.63
.59
1.53
.4997 DIA
FULL R (TYP)
1.16
2.14
2.45
11.88
.35 MIN
.76
SEAL PURGE OUT
BOSS PER AND 10050-4
OIL OUT BOSS
PER AND 10050-6
1.52 (TYP)
3.09
4.685 (REF)
-A- (REF)
VIEW D-D

77 (3)

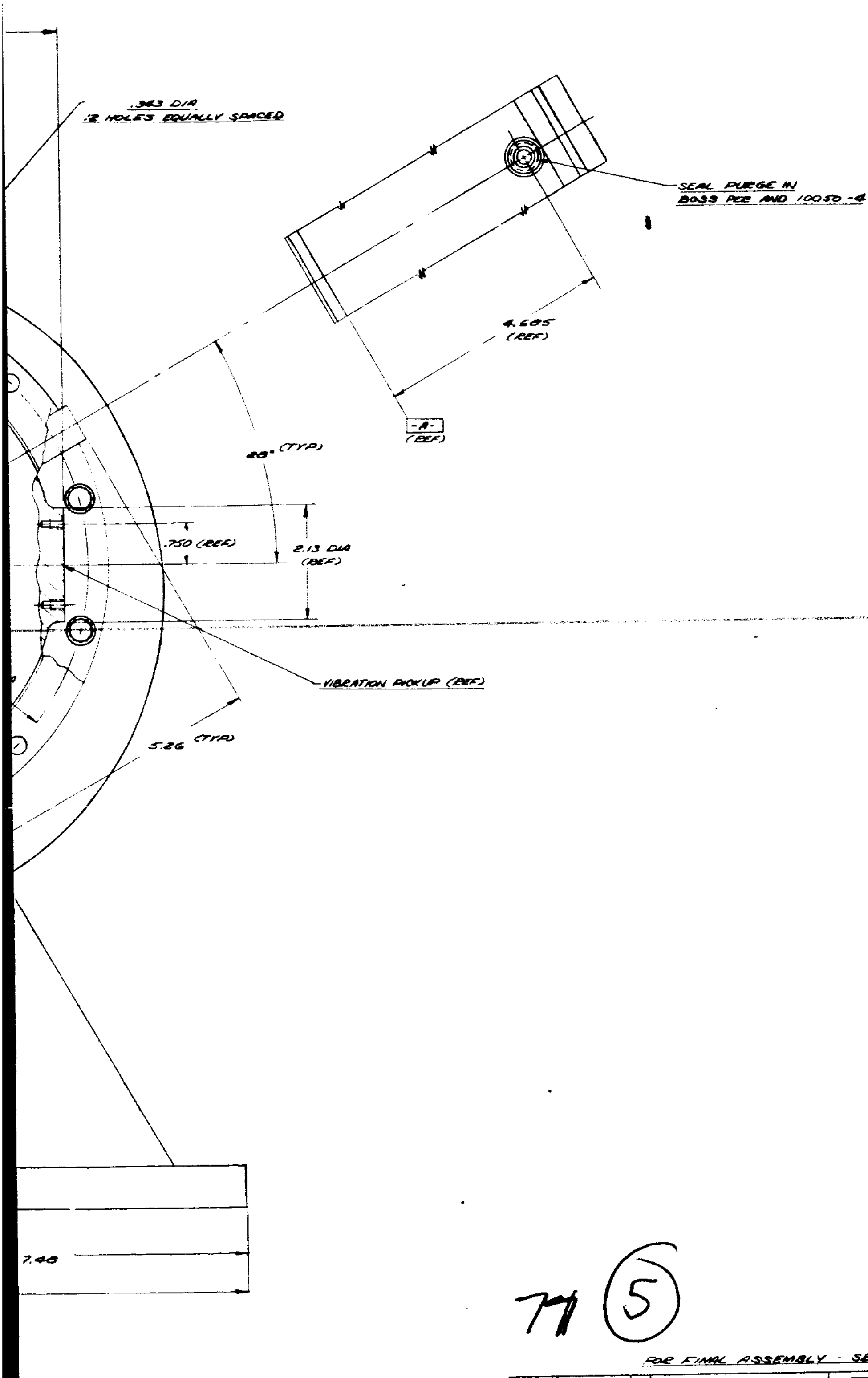


11. LUBRICATION REQUIREMENTS
0.60 GAL PER MIN. OF OIL
60-80 PSIG & 150° F

10. MAY BE PURCHASED FROM CONS
CORPORATION ; PASADENA, CA

77 4

369730 1/1



7M (5)

FOR FINAL ASSEMBLY - SEE 369731

...:
...E MIL-L-7808 AT
...D.
...OLIDATED ELECTRODYNAMICS
...INC..

9. POSITIONAL & GEOMETRICAL TOLERANCE SYMBOLS PER MIL-STD-8.

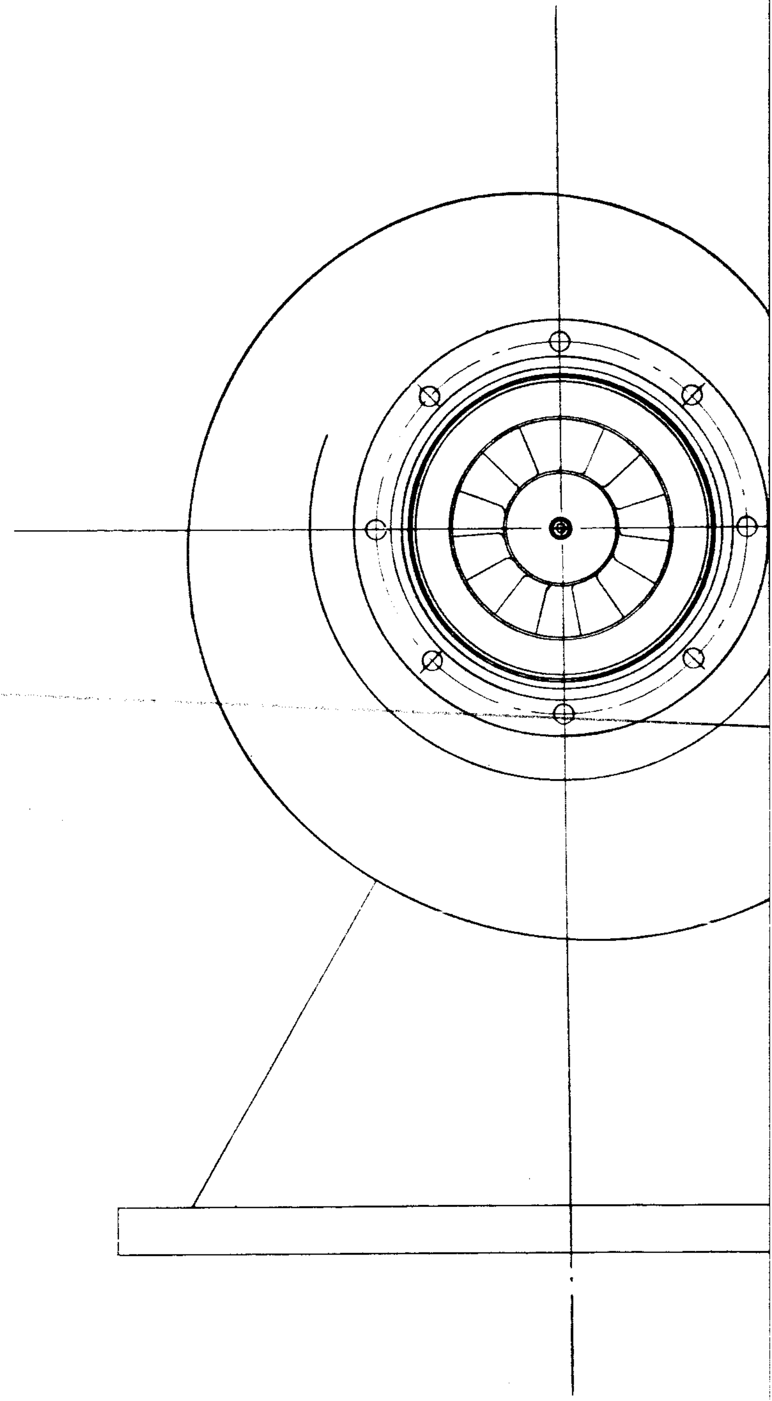
8. MACHINED SURFACES FLAT WITHIN .005 PER INCH TO A MAX. OF .015 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .030 TIR.
5. DIMENSION LIMITS HOLD AFTER PLATING.
4. MACHINED FILLET RADII .005-.015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO.	PART NO.	SYM.	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT	ZONE
	← ASSYS			LIST OF MATERIAL					

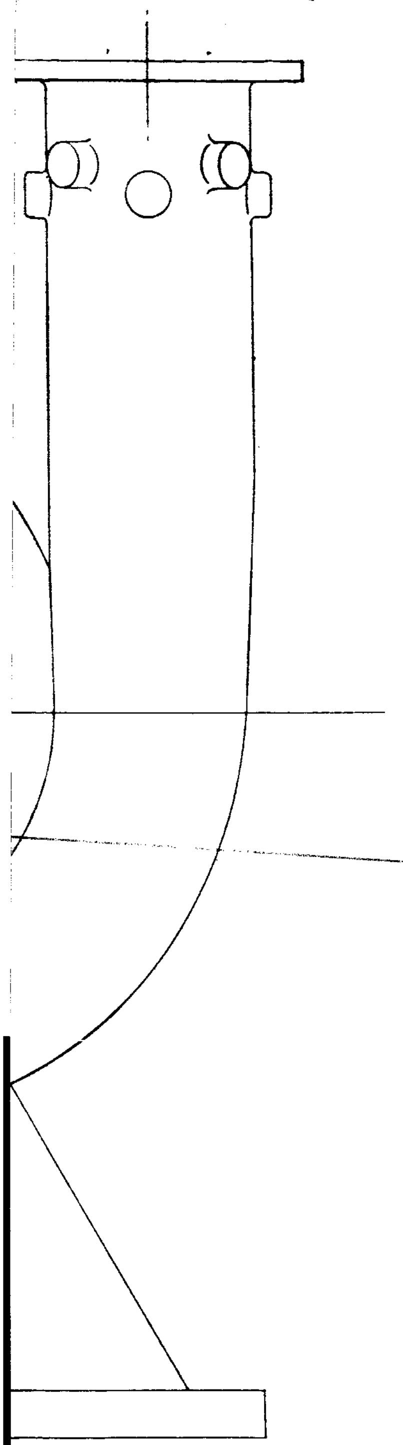
SIGNATURES	DATES	AiResearch Manufacturing Company of Arizona
DFT [signature]	11-11-63	DWG TITLE
CHK [signature]	1-7-64	COMPRESSOR OUTLINE
		TEST, BRAYTON CYCLE
APP [signature]	1-9-64	
[signature]	1-7-64	CODE IDENT NO. 99193 · SIZE J · DWG NO. 369730
		SCALE FULL & HALF · WT —— · SHEET 1 OF 1

REQD	NEXT ASSY	USED ON
HEAT TREATMENT	PROCESS	

SY-5569-R4



78 -0



THESE SURFACES TO BE PARALLEL

NOTE: REMOVE MATERIAL FROM THIS SIDE ONLY TO BE FLAT

NOTE: USE 10LB THRUST IN

GRIND AT ASSEMBLY TO C
.010 (REF) AXIAL WA

THIN DENSE CHROMEPLA
DIMEN

APPLY AFTER PLATIN
OBLITERATED AFTER
PER 369745 IN ACCO
MC-14, CLASS II (REF)

VIEW B

369745 SPACER SEE VIEW "B" 1 REQ

369758 DIFFUSER 1 REQ'D

S8171AP102 "O" RING 1 REQD

MS24673-2 SCREW 12 RE
LOCKWIRE PER NOTE 10
TIGHTENING TORQUE 30-25

369753 SEAL ASSY 1 RE
SEE DETAIL "C" FOR ALTERNATE SEAL

369733 MOUNT 1 RE

369771 WASHER 1 REQ

1 525-518-9047 NUT 1 RE

1 655-601-9208 SCREW 1 RE

369770 SPINNER 1 REQ

369747 IMPELLER 1 RE

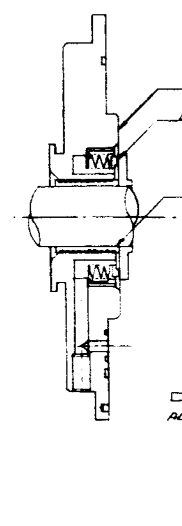
369754 SHAFT 1 RE

1 362-522-9002 SEAL 2 R

369757 SCROLL ASSY 1 RE

369759-3,-5,-7 SHIM AS EE
SHIM TO OBTAIN .002 CRUSH
ON DIFFUSER VANES

AN5C-12 SCREW 12 RE
MS21045 C5 NUT 12 RE
AN960C516L WASHER 12 RE
TIGHTING TORQUE 160-50 IN LB



369737
NOTE: DO
INSTALLI
1 358320
NOTE: TH
OF
369737

369729

DETAIL C
ALTERNATE SE

78-②

4 | 3

2 REQ'D.

4 REQ'D

1 REQ'D

REQ'D

369735 CARRIER 1 REQ'D

111917 SPRING 1 REQ'D

369734 CARRIER 1 REQ'D

369743-1,-2,-3 SHIM AS REQ'D
TO OBTAIN .002 GAP (REF) WITH THRUST APPLIED
IN DIRECTION OPPOSITE ARROW. THIS GAP IS TO BE DETERMINED
BEFORE 525-577-9006 NUT (REF) IS TIGHTENED ON SHAFT.

MS 28561-235 O-RING 1 REQ'D

△1 358313 BEARING 2 REQ'D

△1 358319 SEAL 1 REQ'D
NOTE: THIS SEAL HAS A SHRINK
FIT OF .002 WITH BORE IN
369727 (REF) SEAL CARRIER

AN3CH5A SCREW 6 REQ'D
LOCKWIRE PER NOTE 10

369732 SPACER 1 REQ'D

369746 SHAFT 1 REQ'D
NOTE: THIS IS A LOOSE PART.
CARE MUST BE TAKEN TO PREVENT
DAMAGE DURING HANDLING

△1 525-577-9006 NUT 1 REQ'D
TORQUE TO 300-350 IN LB.

369723 SPACER 1 REQ'D

369727 CARRIER 1 REQ'D
NOTE: DO NOT HEAT ABOVE 400°F
WHEN INSTALLING 358319 (REF.) SEAL

369744-1,-2,-3 SHIM AS REQ
SHIM TO OBTAIN .393-.375 DIM (REF)

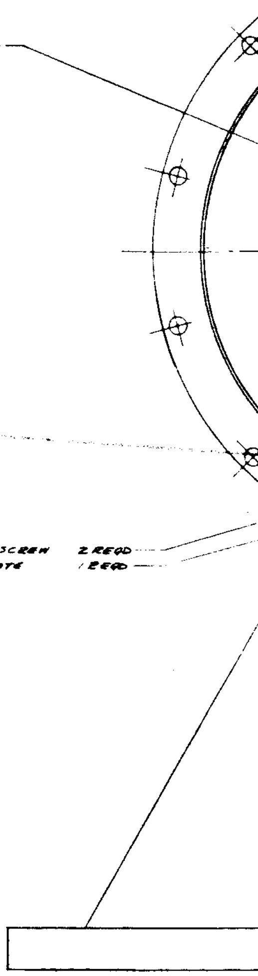
MS 24630-2 TYPE "F" SCREW 2 REQ'D
58860C1P1 NAMEPLATE 1 REQ'D

369722 HOUSING ASSY 1 REQ'D

MS16555-646 PIN (REF)

AN6CN10A SCREW 4 REQ'D
AN960C616 WASHER 4 REQ'D
LOCKWIRE PER NOTE 10

369752 STAND 1 REQ'D



78-(4)

12. TORQUE VALUES GIVEN ARE
FRICTION TORQUE DEVELOP
IS TO BE ADDED TO FAST
BE DETERMINED FOR EA

11. LUBRICATE ALL THREADS
COMPOUND BEFORE ASSEM

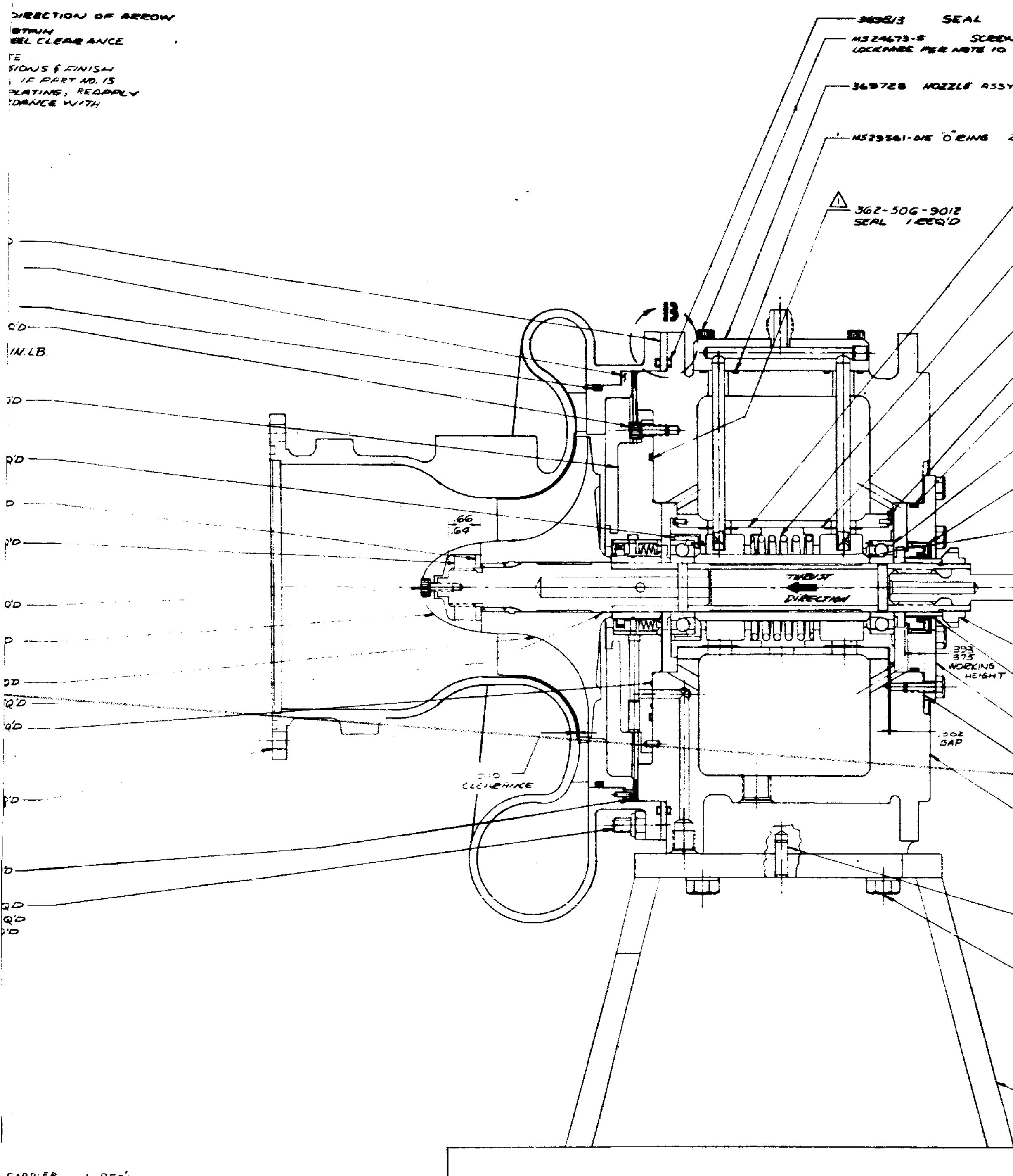
10. LOCKWIRE PER MS 33540

△1 9 VENDOR ITEM: SEE APPLICABL

369731 | SHEET 1 OF 1

4 | 3

DIRECTION OF ARROW
BTAIN
EL CLEARANCE
TE
SIONS & FINISH
, IF PART NO. 15
PLATING, REAPPLY
DANCE WITH



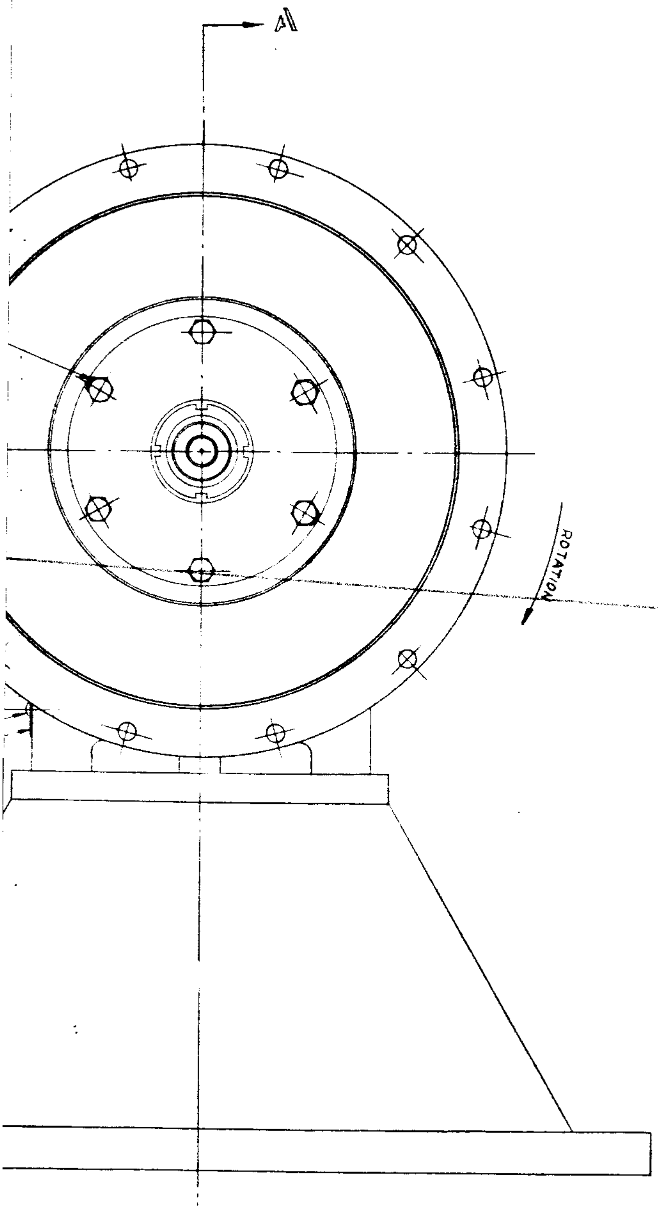
SECTION A-A

CARRIER 1 REQ'D
NOT HEAT ABOVE 500°F WHEN
G 358320 (REF). SEAL
SEAL 1 REQ'D
S SEAL HAS A SHRINK FIT
.0005 WITH BORE IN
(REF.) CARRIER

SPACER 1 REQ'D

78-3

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		SEE ENGINEERING ORDER	1-2-64	[illegible]



18-5

OR FASTENER LOADING
FROM SELF-LOCKING DEVICES
IER LOADING TORQUE & MUST
FASTENER.

H 219-023-9001

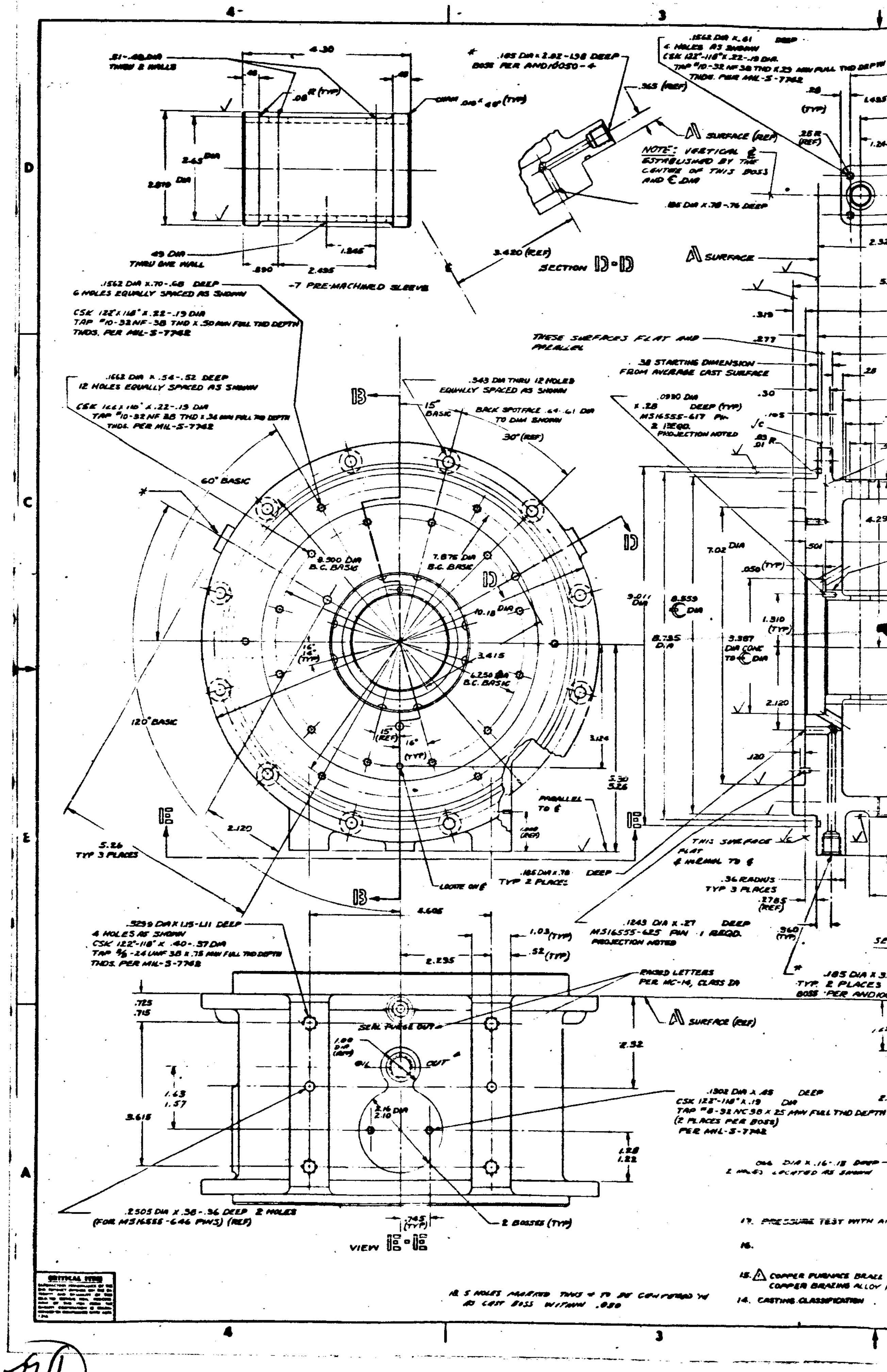
VG MS20995C32 LOCKWIRE
PECIFICATION OR SOURCE CONTROL DWG

8. MACHINED SURFACES FLAT WITHIN [illegible] PER INCH TO A MAX. OF [illegible] FOR ANY SURFACE.
7. MACHINED SURFACES [illegible] OR PARALLEL WITHIN [illegible] PER INCH TO A MAX. OF [illegible] FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN [illegible] TIR. UNMACHINED DIAS. CONCENTRIC WITHIN [illegible] TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET [illegible]
3. BREAK ALL CORNERS AND SHARP EDGES [illegible] MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT	ZONE
	← ASSYS			LIST OF MATERIAL					

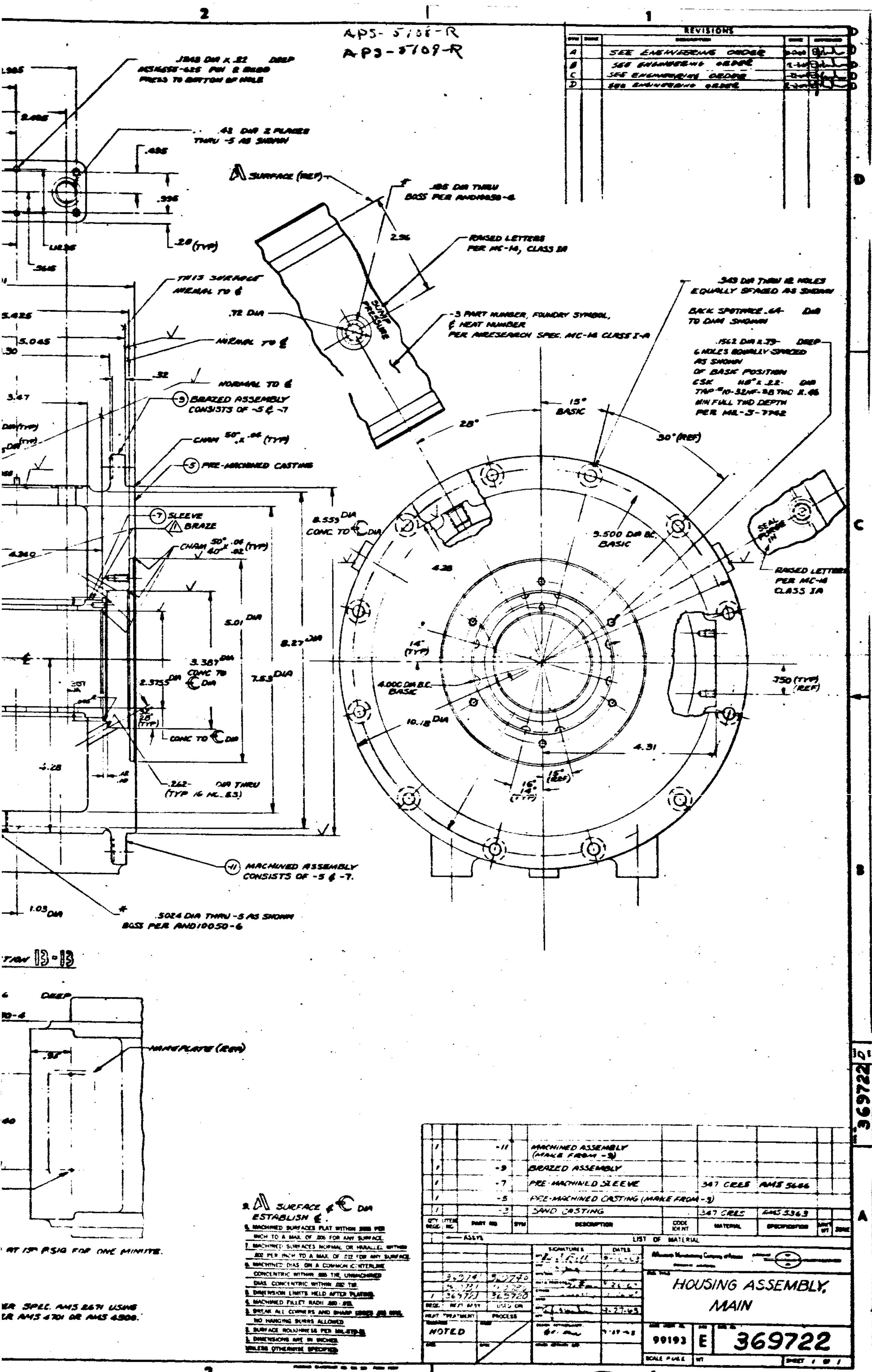
		SIGNATURES	DATES	
		[signature]	10-18-63	AiResearch Manufacturing Company of Arizona
		[signature]	11-12-63	DWG TITLE: COMPRESSOR ASSEMBLY, NASA
	369730			
NEXT ASSY	USED ON	[signature]	12-3-63	
HEAT TREATMENT	PROCESS	[signature]	11-14-63	CODE IDENT NO. 99193 / SIZE J / DWG NO. 369731
				SCALE FULL / WT / SHEET 1 OF 1

DWG NO. 369731 REV A



4
3
D
C
E
A
.51-.48 DIA THRU 2 WALLS
4.30
.08 R (TYP)
2.65 DIA
2.870 DIA
.49 DIA THRU ONE WALL
.890
2.495
1.245
-7 PRE-MACHINED SLEEVE
* .185 DIA x 2.82-1.38 DEEP BOSS PER AND10050-4
.365 (REF)
A SURFACE (REF)
NOTE: VERTICAL ℄ ESTABLISHED BY THE CENTER OF THIS BOSS AND ℄ DIA
.186 DIA x .78-.76 DEEP
3.420 (REF)
SECTION D-D
A SURFACE
.1562 DIA x .70-.68 DEEP
6 HOLES EQUALLY SPACED AS SHOWN
CSK 122°x118° x .22-.19 DIA
TAP #10-32 NF-3B THD x .50 MIN FULL THD DEPTH
THDS. PER MIL-S-7742
.1562 DIA x .54-.52 DEEP
12 HOLES EQUALLY SPACED AS SHOWN
CSK 122°x118° x .22-.19 DIA
TAP #10-32 NF 3B THD x .34 MIN FULL THD DEPTH
THDS. PER MIL-S-7742
THESE SURFACES FLAT AND PARALLEL
.38 STARTING DIMENSION FROM AVERAGE CAST SURFACE
.343 DIA THRU 12 HOLES EQUALLY SPACED AS SHOWN
15° BASIC
BACK SPOTFACE .64-.61 DIA TO DIM SHOWN
30° (REF)
.0930 DIA x .28 DEEP (TYP)
MS16555-617 PIN
2 REQD.
PROJECTION NOTED
60° BASIC
8.500 DIA B.C. BASIC
7.876 DIA B.C. BASIC
10.18 DIA
3.415
6.250 DIA B.C. BASIC
120° BASIC
15° (REF)
16° (TYP)
7.02 DIA
9.011 DIA
8.559 ℄ DIA
8.735 DIA
3.387 DIA CONE TO ℄ DIA
1.310 (TYP)
2.120
.050 (TYP)
.501
4.29
.319
.277
.28
.30
.105
PARALLEL TO ℄
5.30
5.26
3.124
1.000 (REF)
2.120
5.26 TYP 3 PLACES
THIS SURFACE FLAT ℄ NORMAL TO ℄
.36 RADIUS TYP 3 PLACES
.2785 (REF)
.360 (TYP)
.185 DIA x .78 DEEP TYP 2 PLACES
LOCATE ON ℄
.1243 DIA x .27 DEEP
MS16555-625 PIN 1 REQD.
PROJECTION NOTED
.5299 DIA x 1.15-1.11 DEEP
4 HOLES AS SHOWN
CSK 122°-118° x .40-.37 DIA
TAP 5/16-24 UNF 3B THD x .75 MIN FULL THD DEPTH
THDS. PER MIL-S-7742
4.605
1.03 (TYP)
.52 (TYP)
2.235
RAISED LETTERS PER MC-11, CLASS 2A
SEAL PURGE OUT
OIL OUT
A SURFACE (REF)
.725
.715
2.32
1.63
1.57
3.615
2.16
2.10 DIA
1.28
1.22
.1302 DIA x .45 DEEP
CSK 122°-118° x .19 DIA
TAP #8-32 NC 3B x .25 MIN FULL THD DEPTH
(2 PLACES PER BOSS)
PER MIL-S-7742
.2505 DIA x .38-.36 DEEP 2 HOLES
(FOR MS16555-646 PINS) (REF)
.745 (TYP)
2 BOSSES (TYP)
VIEW E-E
17. PRESSURE TEST WITH
16.
15. COPPER FURNACE BRAZE
COPPER BRAZING ALLOY
14. CASTING CLASSIFICATION
18. 5 HOLES MARKED THUS * TO BE CONCENTRIC W/ AS CAST BOSS WITHIN .030
CRITICAL ITEM

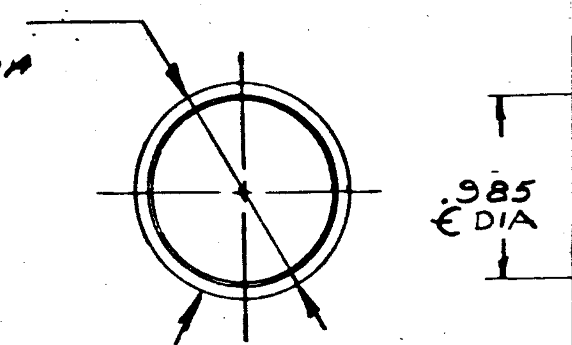
1


APS-5708-R
APS-5709-R
REVISIONS
A SEE ENGINEERING ORDER
B SEE ENGINEERING ORDER
C SEE ENGINEERING ORDER
D SEE ENGINEERING ORDER
.1868 DIA X .22 DEEP MS16555-625 PIN 2 PLACES PRESS TO BOTTOM OF HOLE
.41 DIA 2 PLACES THRU -5 AS SHOWN
SURFACE (REF)
.186 DIA THRU BOSS PER AND10050-4
RAISED LETTERS PER MC-14, CLASS IA
SUMP PRESSURE
THIS SURFACE NORMAL TO ℄
.72 DIA
NORMAL TO ℄
-3 PART NUMBER, FOUNDRY SYMBOL, & HEAT NUMBER PER AIRESEARCH SPEC. MC-14 CLASS I-A
NORMAL TO ℄
(9) BRAZED ASSEMBLY CONSISTS OF -5 & -7
CHAM 50° X .06 (TYP)
(5) PRE-MACHINED CASTING
(7) SLEEVE
BRAZE
.343 DIA THRU 12 HOLES EQUALLY SPACED AS SHOWN
BACK SPOTFACE .64 DIA TO DIM SHOWN
.1562 DIA X .39 DEEP 6 HOLES EQUALLY SPACED AS SHOWN OF BASIC POSITION
TAP #10-32NF-3B THD X .46 MIN FULL THD DEPTH PER MIL-S-7742
15° BASIC
28°
30° (REF)
8.553 DIA CONC TO ℄ DIA
9.500 DIA B.C. BASIC
SEAL FORCE IN
RAISED LETTERS PER MC-14 CLASS IA
5.01 DIA
8.27 DIA
7.63 DIA
3.387 DIA CONC TO ℄ DIA
2.3755 DIA
CONC TO ℄ DIA
14° (TYP)
4.000 DIA B.C. BASIC
10.18 DIA
.750 (TYP) (REF)
4.31
16° (REF)
14° (TYP)
.262 DIA THRU (TYP 16 HOLES)
(11) MACHINED ASSEMBLY CONSISTS OF -5 & -7.
.5024 DIA THRU -5 AS SHOWN BOSS PER AND10050-6
SECTION B-B
1.03 DIA
NAMEPLATE (REF)
AT 15 PSIG FOR ONE MINUTE.
PER SPEC. AMS 2671 USING PER AMS 4701 OR AMS 4508.
9. SURFACE & ℄ DIA ESTABLISH ℄.
8. MACHINED SURFACES FLAT WITHIN .002 PER INCH TO A MAX OF .005 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .030 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .010-.015.
3. BREAK ALL CORNERS AND SHARP EDGES .005 - .015. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED.
1 -11 MACHINED ASSEMBLY (MAKE FROM -9)
1 -9 BRAZED ASSEMBLY
1 -7 PRE-MACHINED SLEEVE 347 CRES AMS 5646
1 -5 PRE-MACHINED CASTING (MAKE FROM -3)
1 -3 SAND CASTING 347 CRES AMS 5363
LIST OF MATERIAL
HOUSING ASSEMBLY, MAIN
NOTED
99193 E 369722
SCALE FULL
SHEET 1 OF 1
369722 D

79 (2)

APS-5706-R
APS-5109-R

THESE SURFACES NORMAL TO ℄ DIA &
PARALLEL TO EACH OTHER



11. MAGNETIC INSPECTION PER MIL-I-6868
10.

QTY. REQD.		ITEM NO.	PART NO.	S
		← ASSYS		
1	369741	369740		
1	369731	369730		
1	369721	369720		
REQD.	NEXT ASSY.	USED ON		

HEAT TREATMENT	PROCESS
HARDNESS Rc 40-46	NAME
SPEC.	SPEC.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015.
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

PE844 — SIMPLICRONAFLEX

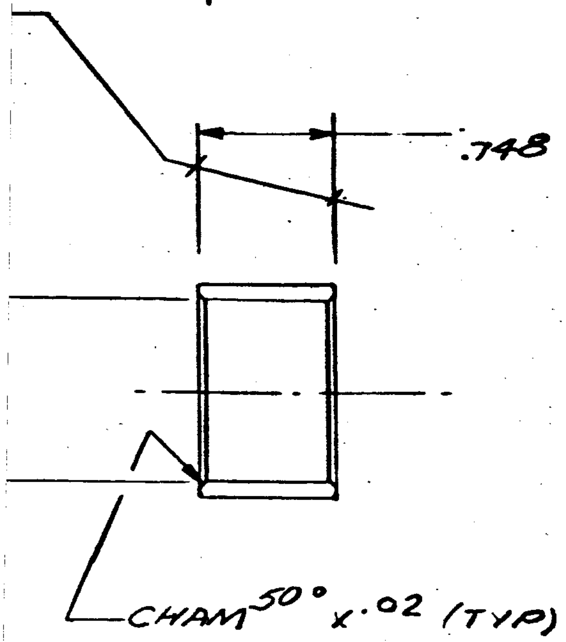
80-0

D

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

LAST LTR. —

DWG. NO. 369723



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR. 1.313.

			4340	AMS 6415	
YM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

LIST OF MATERIAL

SIGNATURES		DATES
DFT.	H. Montgomery	8-24-63
CHK.	[illegible] Ford	8-24-63
MFG. ENG.		
MAT. & PROCESS	[illegible]	9-25-63
STRESS	D. A. Westley	9-25-63
AERO		
APP.	[illegible]	9-26-63
APP.		
DESIGN ACTIVITY APP.	Williams	9-26-63
OTHER ACTIVITY APP.		

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
A Division of THE GARRETT CORPORATION

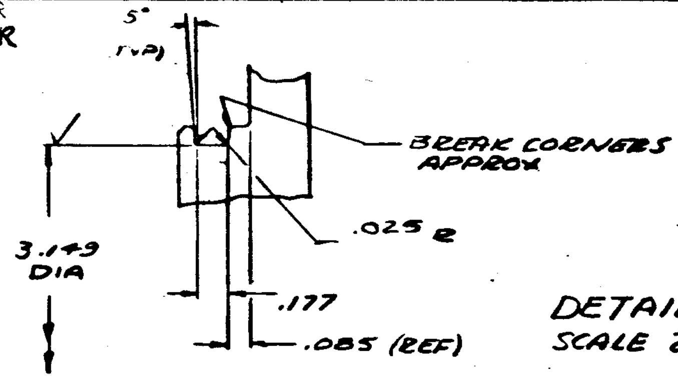
DWG. TITLE
SPACER

CODE IDENT NO.	SIZE	DWG. NO.
99193	B	369723

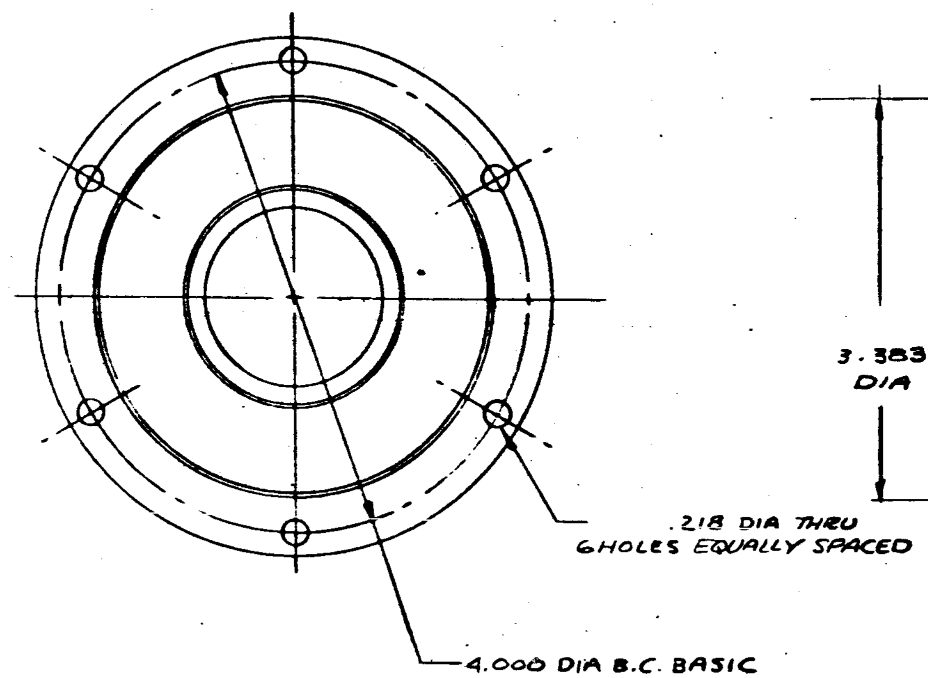
SCALE FULL | WT. | SHEET 1 OF 1

80 2

APS-5108-R
APS-5109-R



DETAIL C
SCALE 2/1



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.312.

11.

10. POSITIONAL & GEOMETRICAL TOLERANCE SYMBOLS PER MIL-STD-8

9.

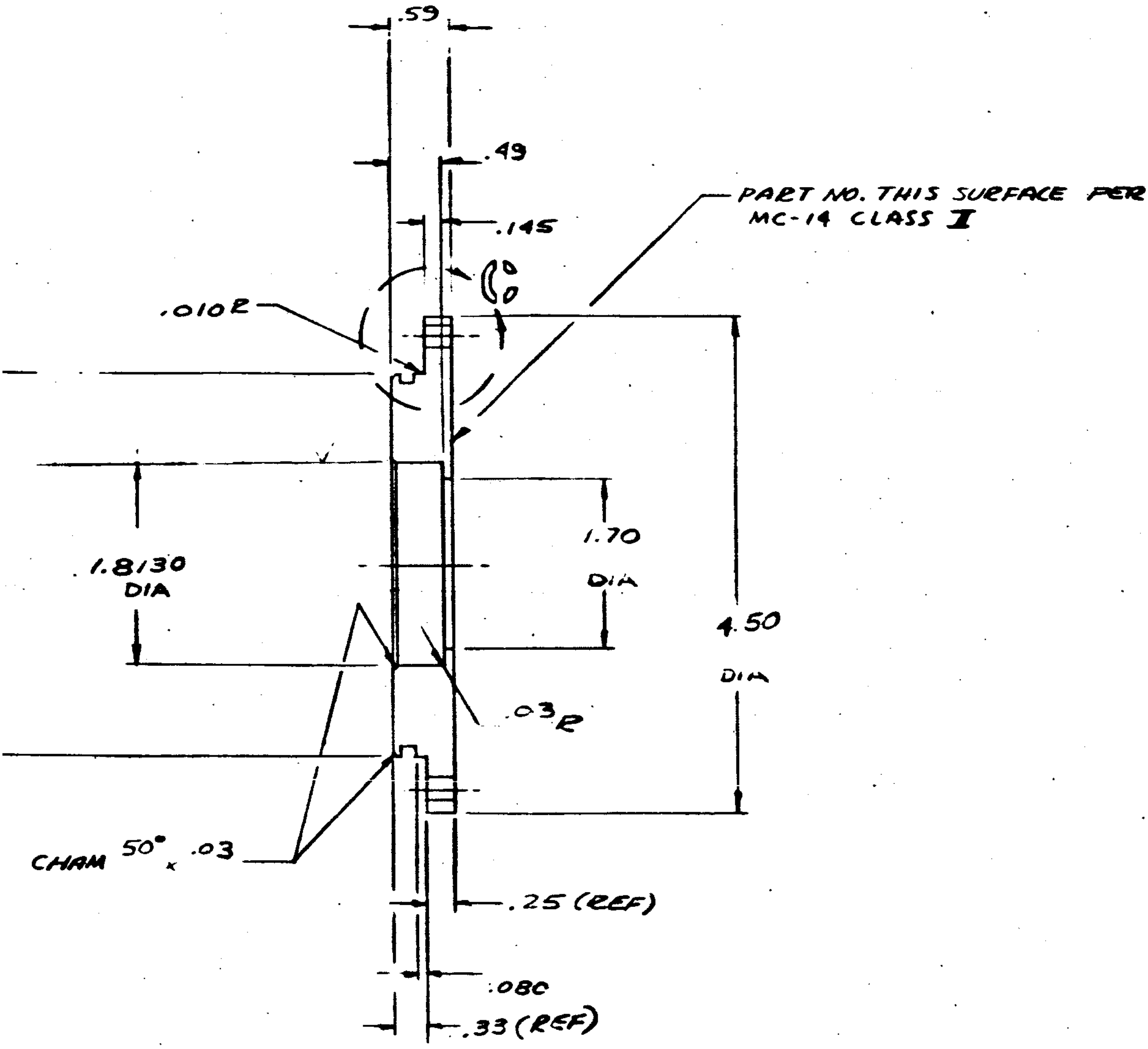
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

P9949 K & E 103 HERCULENE

8 10

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE ENGR ORDER	11-12-63	
B	SEE ENGR ORDER	1-14-64	



LAST LTR B

DWG NO. 369727

TY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
				PLATE		CRES 347	MIL-S-6721	

←ASSYS LIST OF MATERIAL

369741 369740	
369731 369730	
369721 369720	
QD. NEXT ASSY.	USED ON

AT TREATMENT	PROCESS
VOTED	
HT-38	

SIGNATURES	DATES
DFTSMN	9-19-63
CHK	10-1-63
MFG ENG	
MAT & PROCESS	10-16-63
STRESS	10-8-63
AERO	
APP	10-9-63
APP	
DESIGN ACTIVITY APP	10-9-63
OTHER ACTIVITY APP.	

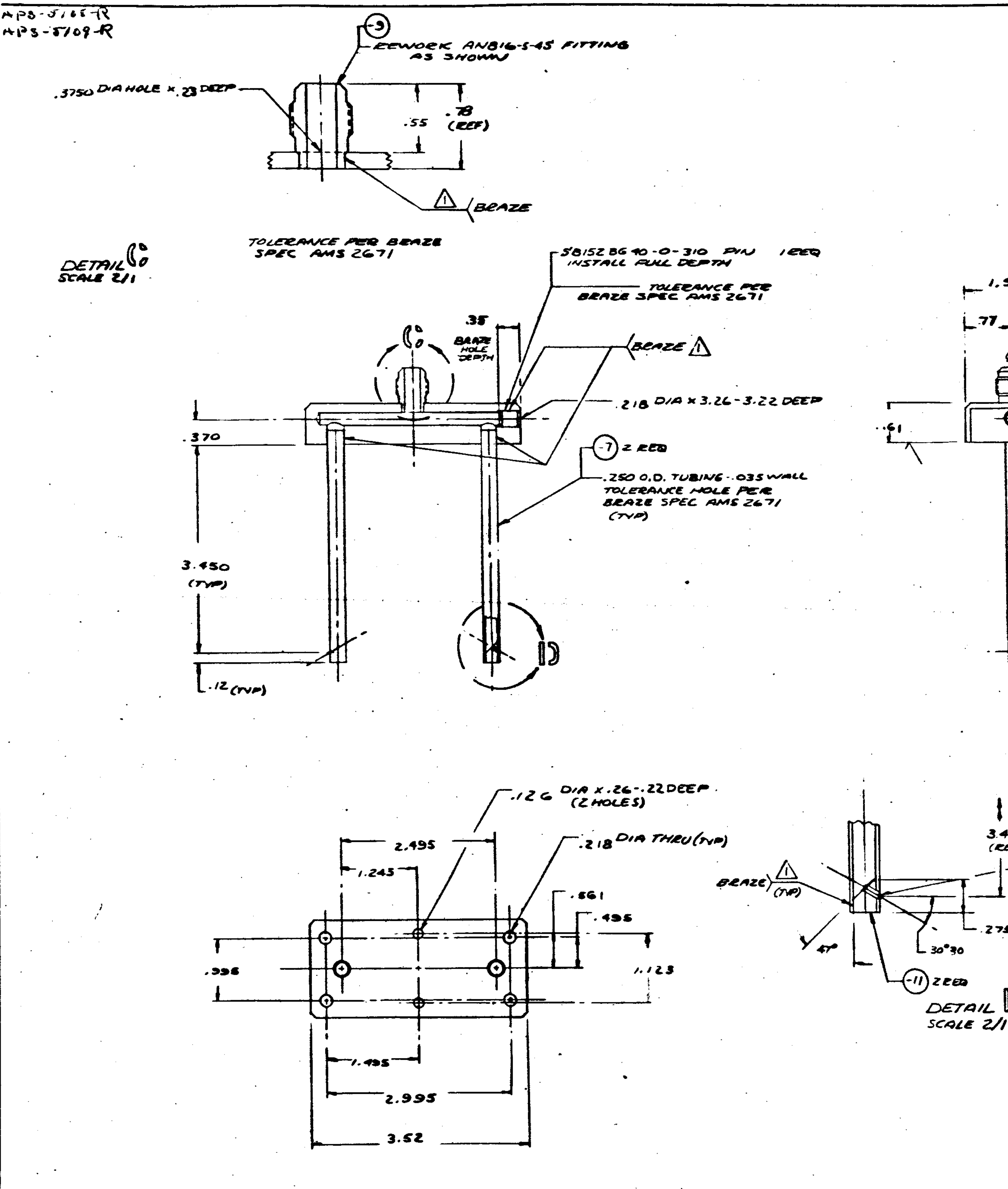
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG TITLE: CARRIER, SEAL

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369727

SCALE FULL | WT. | SHEET 1 OF 1

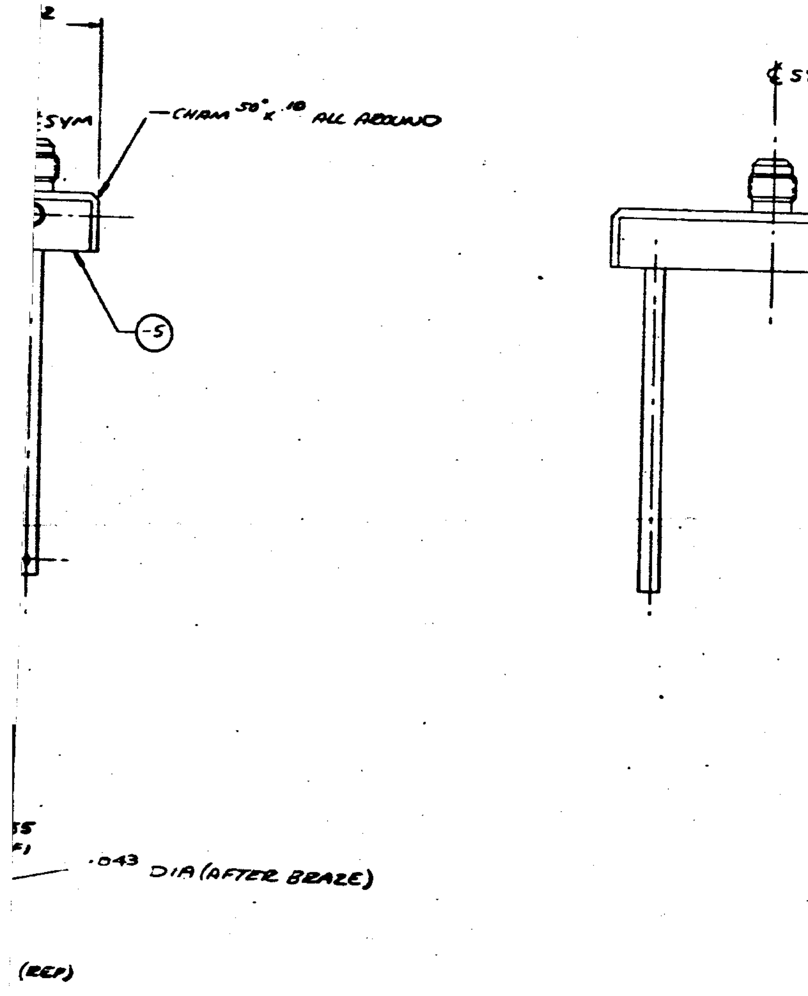
81(2)



11. PRESSURE TEST WITH OIL AT 150 PSIG FOR ONE MINUTE.

10. COPPER BRAZE PER AMS 2671

CRITICAL ITEM



QTY. REQD.	ITEM NO.	PART NO.
2		-11
1		-9
2		-7
1		-5
		-3

ASSYS

REQD	NEXT ASSY.	USED ON
	369741	369740
	369731	369730
1	369721	369720

HEAT TREATMENT | PROCESS

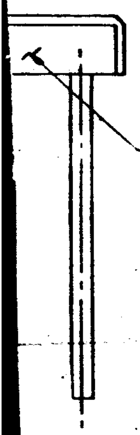
8 MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE
7 MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .012 FOR ANY SURFACE
6 MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR
5 DIMENSION LIMITS HELD AFTER PLATING
4 MACHINED FILLET RADII .030 - .015
3 BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2 SURFACE ROUGHNESS PER MIL-STD-10.
1 DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED

2

82

SYM	DESCRIPTION	DATE	APPROVED
REVISIONS			

...M (EXCEPT .218 DIA (REF) HOLE AS SHOWN)



PART NO. HERE PER MC 14, CLASS II

369728

SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
	ORFICE PLUG		CRES 347	QQ-S-763	
	CONNECTOR				
	TUBE		CRES 347		
	BODY		CRES 347	MIL-S-6721	
	BRAZED ASSY				

LIST OF MATERIAL

SIGNATURES	DATES
	9-19-63
	9-26-63
	9-25-63
	9-27-63
	9-26-63
	9-26-63

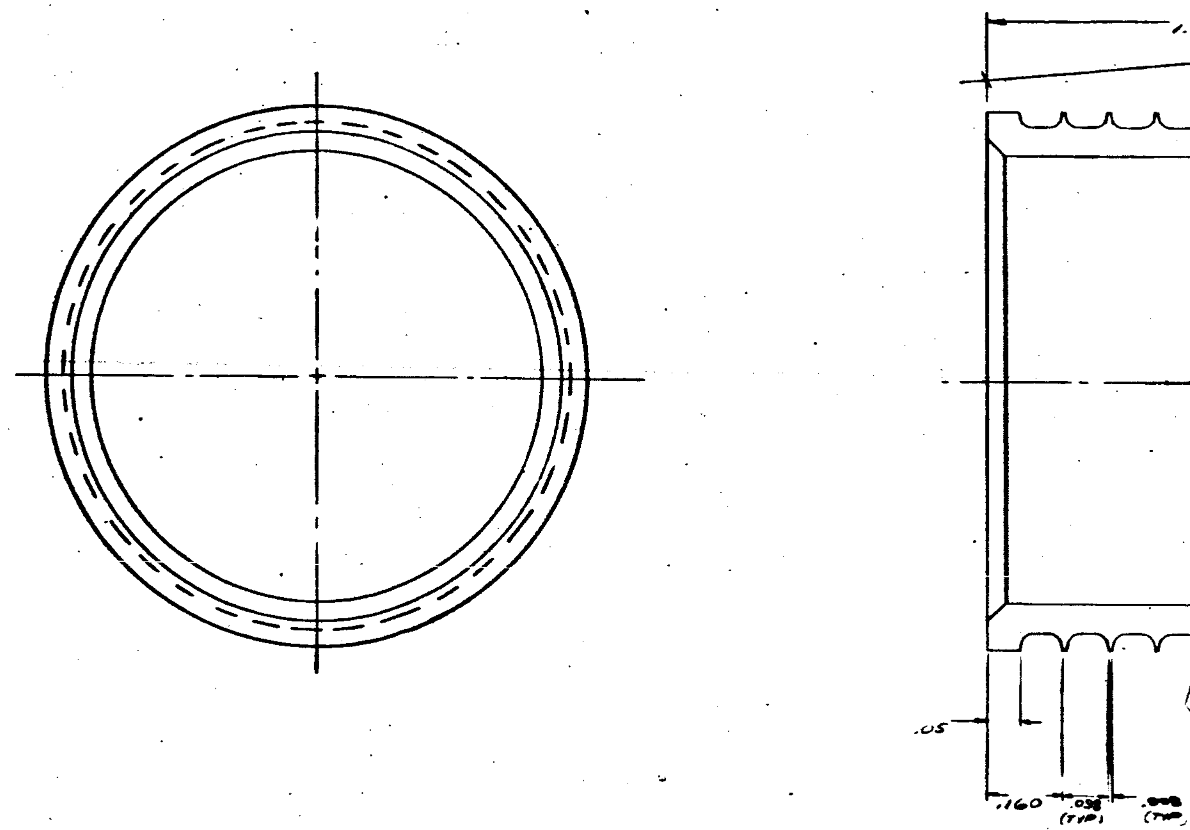
DWG TITLE: NOZZLE ASSEMBLY, OIL

CODE IDENT NO.	SIZE	DWG NO.
99193	D	369728

SCALE FULL | WT. | SHEET

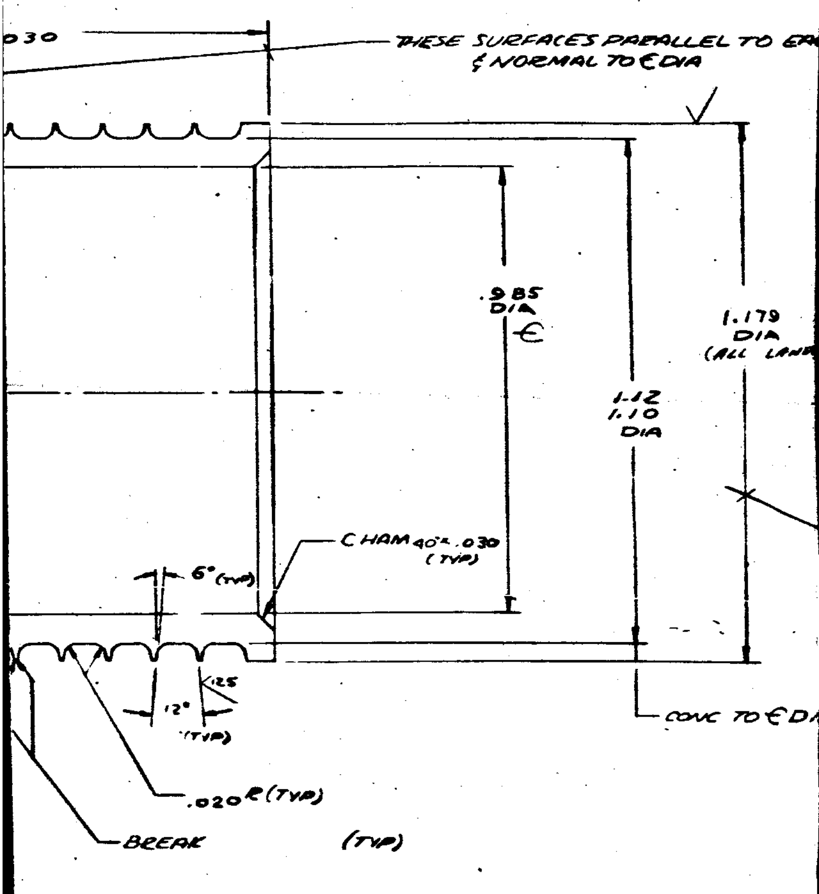
8 2 3

APS-5108-R
APS-5109-R



11. PENETRANT INSPECT PER MIL-I-6866
10. PART NUMBERING: NONE

CRITICAL ITEM
SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1-313.



8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO.	PART NO.
	← ASSYS	
	369741	369740
	369731	369730
1	369721	369720
REQD	NEXT ASSY	USED ON
HEAT TREATMENT		PROCESS
HARDNESS Rc 45-55		NAME
SPEC		SPEC

2

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

CH OTHER

CONCENTRIC TO ℄ DIA

SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
			N5-25		

LIST OF MATERIAL

SIGNATURES	DATES
	9-18-63
	9-25-63
MAT & PROCESS	9-25-63
	9-25-63
	9-26-63
ACTIVITY APP	9-26-63
ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona

DWG. TITLE: SPACER, LABYRYNTH

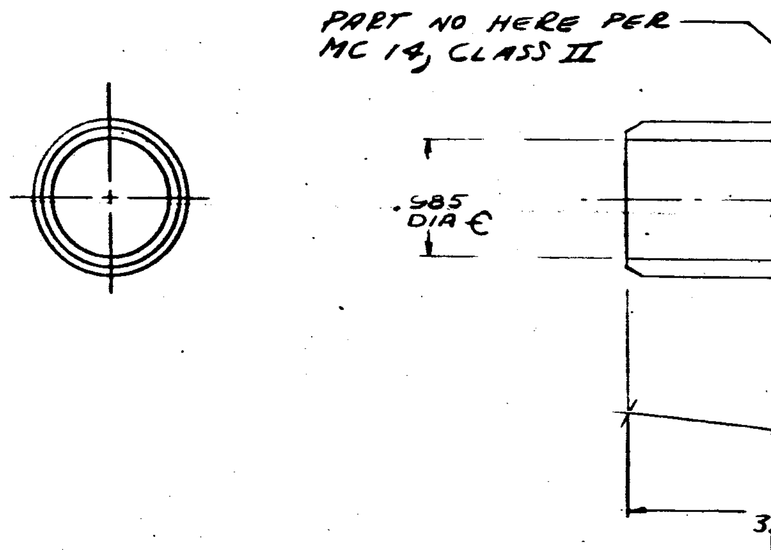
CODE IDENT NO. 99193 | SIZE D | DWG. NO. 369729

SCALE 5/1 | WT. | SHEET 1 OF 1

369729

93(2) 3

APS-5108-R
APS-5109-R



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

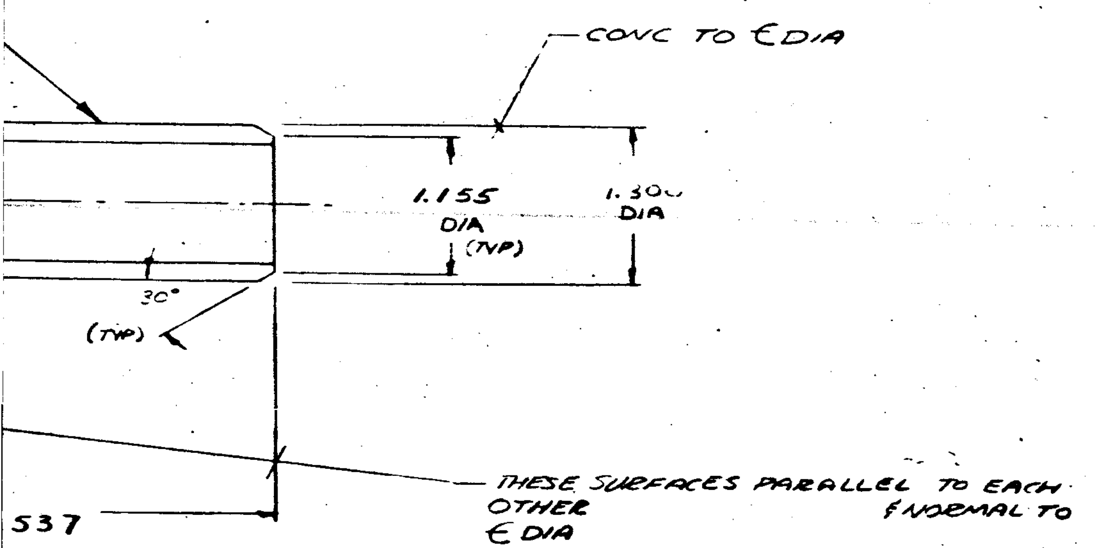
12.
11. MAGNETIC INSPECTION PER MIL-I-6868
10. SIMILAR ~~TO~~ 369539
9

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ~~ALL~~ CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

8 4/10

SYM	REVISIONS DESCRIPTION	DATE	APPROVED



Y. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
				BAR OR TUBING		STEEL 4340	AMS 6415	

←ASSYS — LIST OF MATERIAL

	NEXT ASSY.	USED ON
	369741	369740
	369731	369730
	369721	369720

T TREATMENT	PROCESS
:46-40	NAME
-H-6875	SPEC.

SIGNATURES		DATES
DFTS.	[signature]	9-16-63
CHK.	Crawford	9-25-63
MFG. ENG.		
MAT. & PROCESS	[signature]	9-25-63
STRESS	[signature]	9-25-63
AERO		
APP.	[signature]	9-26-63
APP.		
DESIGN ACTIVITY APP.	[signature]	9-26-63
OTHER ACTIVITY APP.		

AiResearch Manufacturing Company of Arizona, Phoenix, Arizona

DWG. TITLE: SPACER, BEARING

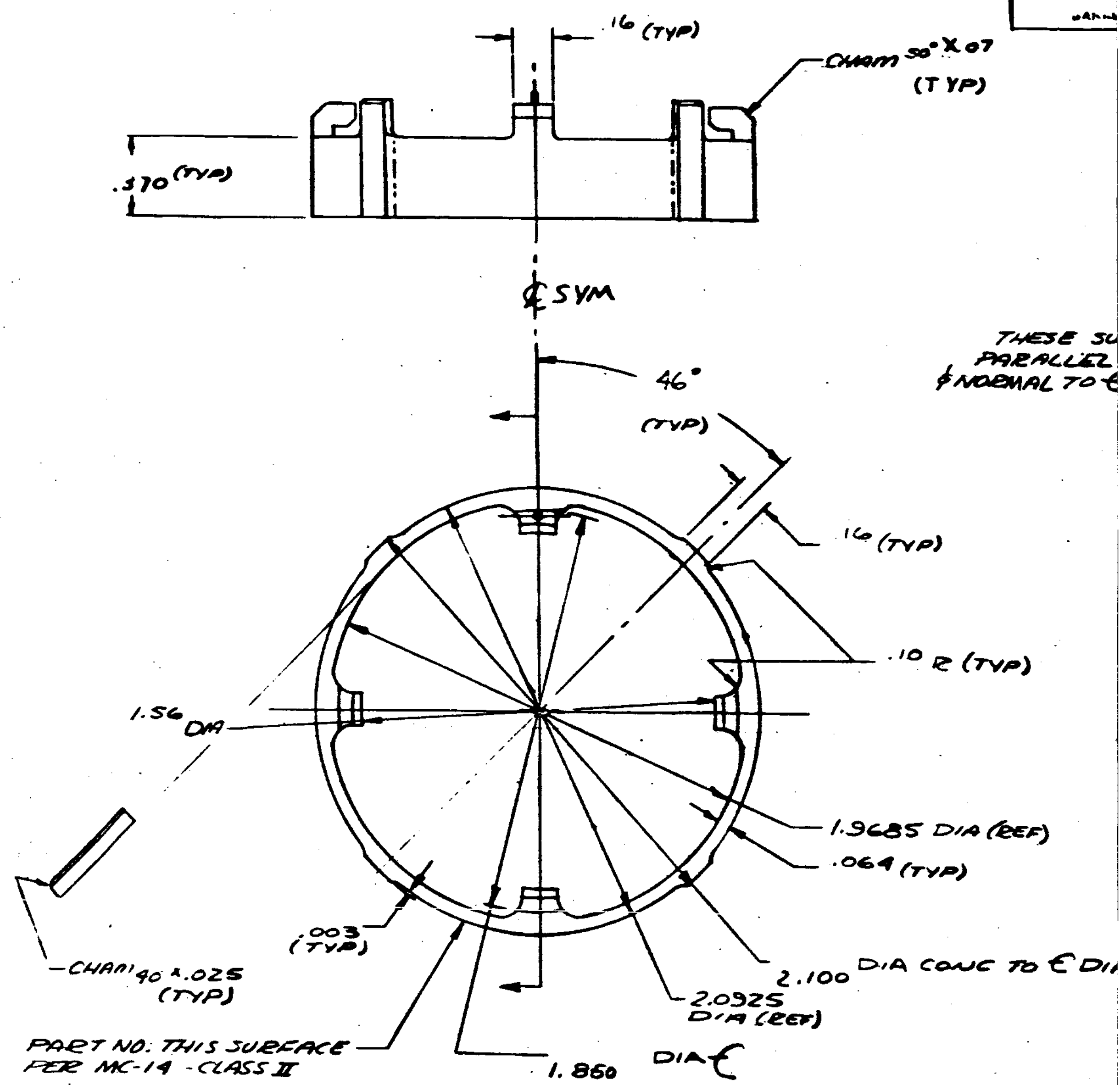
CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369732

SCALE FULL | WT. | SHEET 1 OF 1

DWG NO 369732

84 (2)

APS-5168
APS-5169-R



CRITICAL ITEM

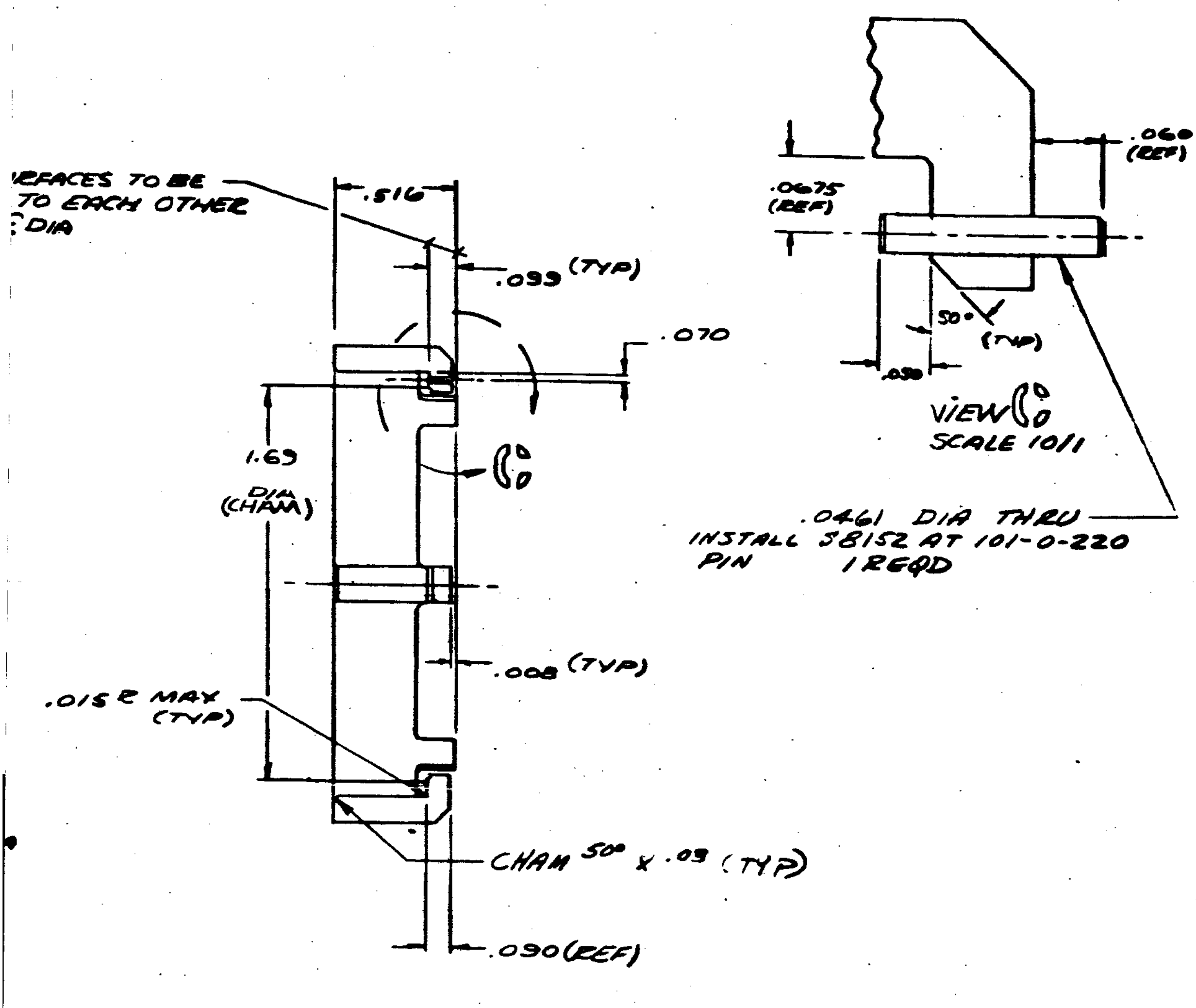
SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

12. CONCENTRICITY SHOWN NEED NOT BE CHECKED IN FREE STATE.
11. MAGNETIC INSPECTION PER MIL-I-6868
10. SIMILAR TO PA 369572
9.
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES

UNLESS OTHERWISE SPECIFIED.

85 (1)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
				BAR		STEEL 4340	AMS 6415	
←ASSYS								

LIST OF MATERIAL

		SIGNATURES	DATES
		DFT. [signature]	9-17-63
		CHK. [signature]	9-25-63
369741	369740	MFG. ENG.	
369731	369730	MAT. & PROCESS [signature]	9-25-63
369721	369720	STRESS [signature]	9-25-63
		AERO	
QD. NEXT ASSY.	USED ON	APP. [signature]	9-26-63
HEAT TREATMENT	PROCESS	APP.	
HARDNESS	NAME	DESIGN ACTIVITY APP. [signature]	9-26-63
...C	SPEC.	OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
MOUNT, BEARING - RESILIENT

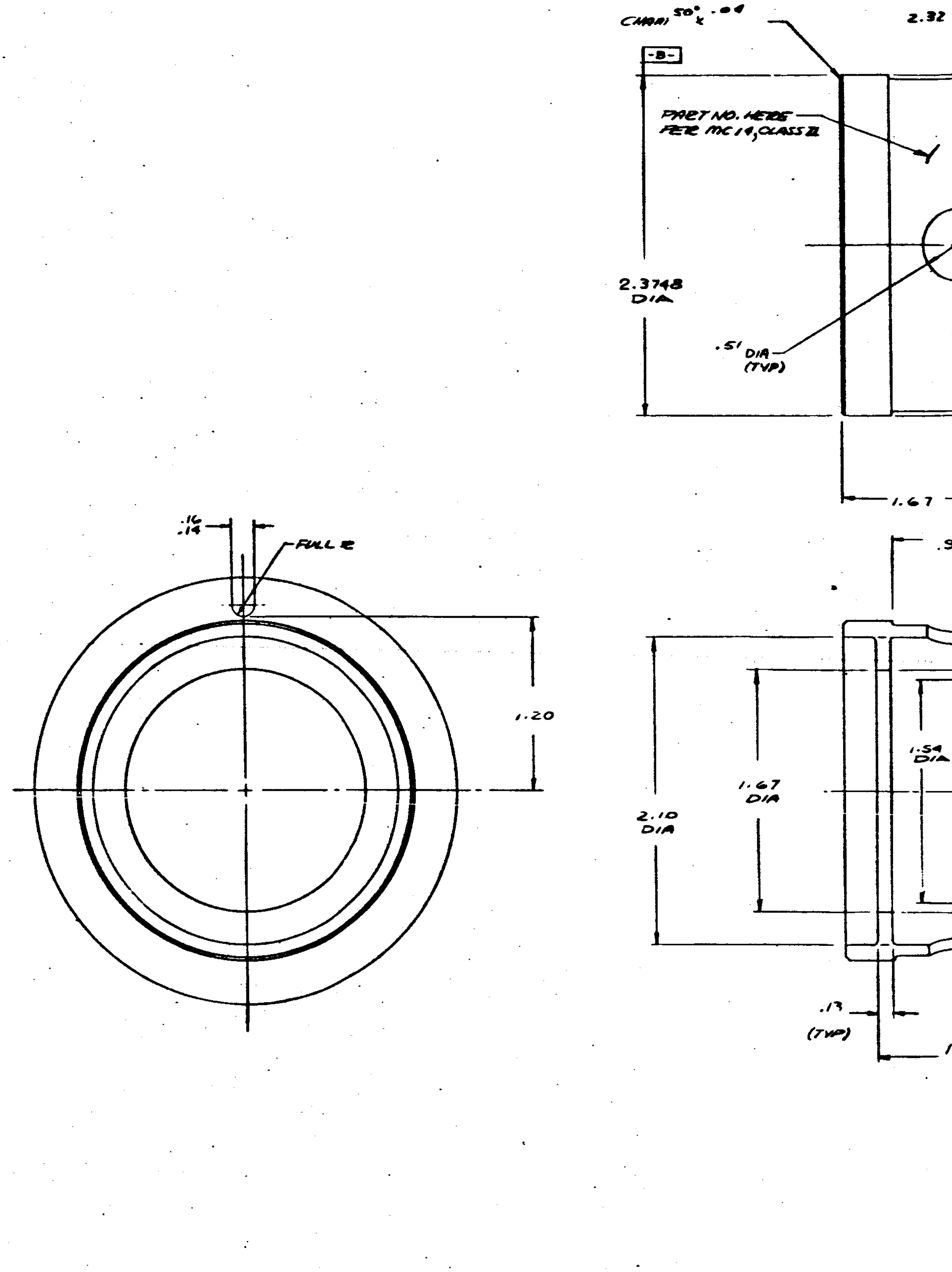
CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369733

SCALE 2/1 | WT. | SHEET 1 OF 1

DWG. NO. 369733 | LAST LTR. —

85 (2)

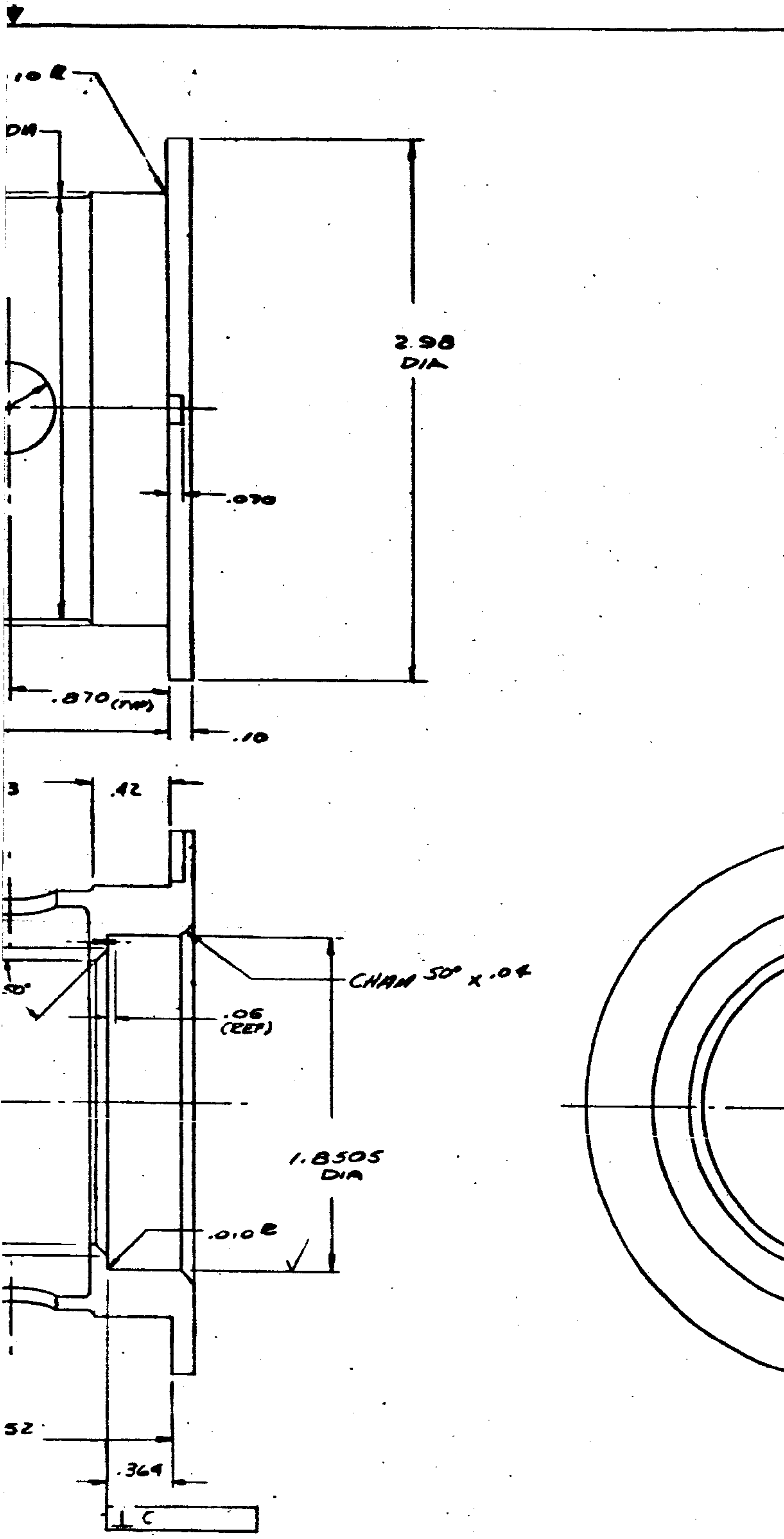
APS-5108-R
APS-5109-R



CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.312

12. POSITIONAL & GEOMETRIC SYMBOLS PER MIL-STD-8
11. SIMILAR TO PA 369573
10. MAGNETIC INSPECTION PER MIL-I-6868



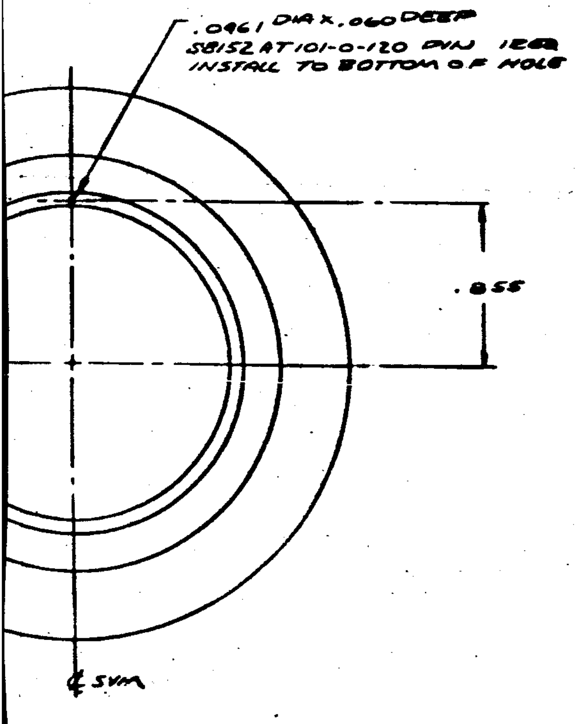
9. *FINISH ALL OVER* 125
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR
5. DIMENSION LIMITS HELD AFTER PLATING
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY. REQD.	ITEM NO.	PART NO.
	←ASSYS	
	369741	369740
	369731	369730
1	369721	369720
REQD.	NEXT ASSY.	USED ON
HEAT TREATMENT		PROCESS
HARDNESS Rc 36-42		NAME
SPEC. MIL-H-6875		SPEC.

2

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE ENGINEERING ORDER		



369734

	BAR		STEEL 4340	AMS 6415	
SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

LIST OF MATERIAL

SIGNATURES	DATES
DR	9-19-63
CHK	9-25-63
MFG. ENG.	
MAT. & PROCESS	9-25-63
STRESS	9-25-63
AERO.	
APP	9-26-63
APP	
DESIGN ACTIVITY APP.	9-26-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

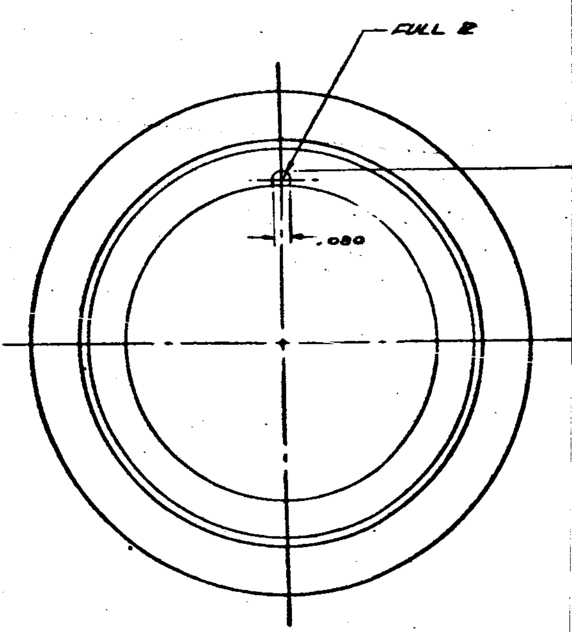
DWG. TITLE
CARRIER, BEARING

CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369734

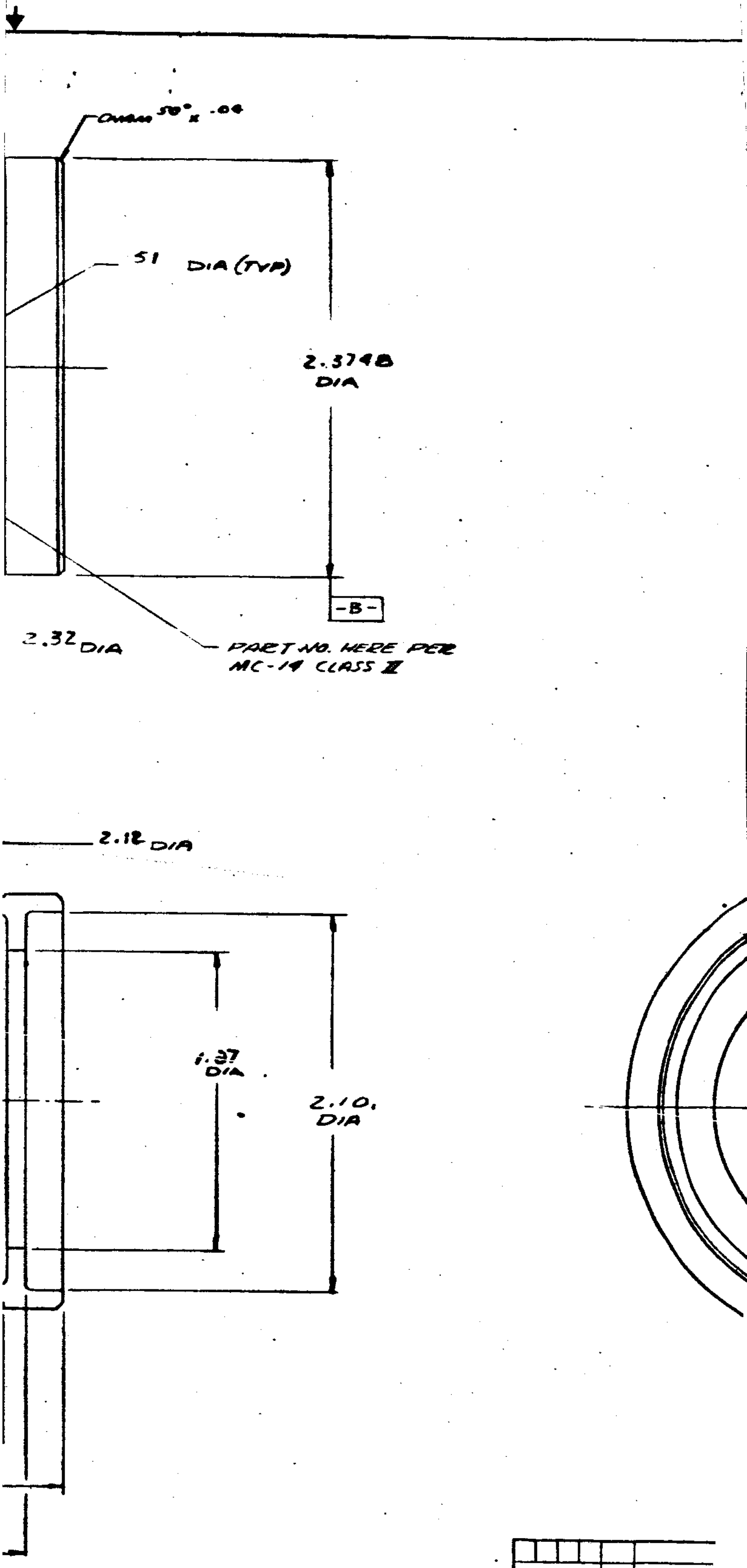
SCALE 2/1 | WT. | SHEET 1 OF 1

85 ⑦ 3

APS-5108-R
APS-5108-R



86 (1)



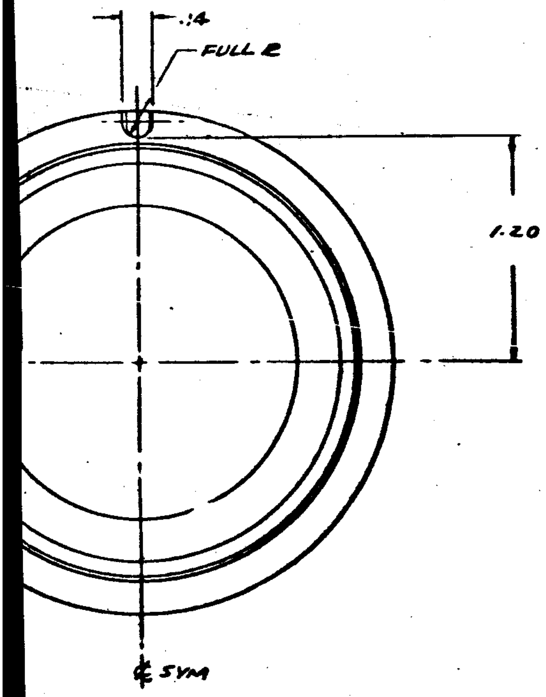
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR. UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY. REQD.	ITEM NO.	PART N
		←ASSYS
	365741	365
	365731	365
1	365721	365
REQD.	NEXT ASSY	US
HEAT TREATMENT		PRO
HARDNESS Rc 36-42		NAME
SPEC. MIL-H-6875		SPEC.

3

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE ENGINEERING ORDER	1-5-64	



SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
	BAR		STEEL 4340	AMS 6415	

LIST OF MATERIAL

SIGNATURES		DATES
DFT.		9-?-63
CHK.		9-25-63
MFG. ENG.		
MAT. & PROCESS		9-25-63
STRESS		9-25-63
AERO.		
APP.		9-26-63
APP.		
DESIGN ACTIVITY APP.		9-26-63
OTHER ACTIVITY APP.		

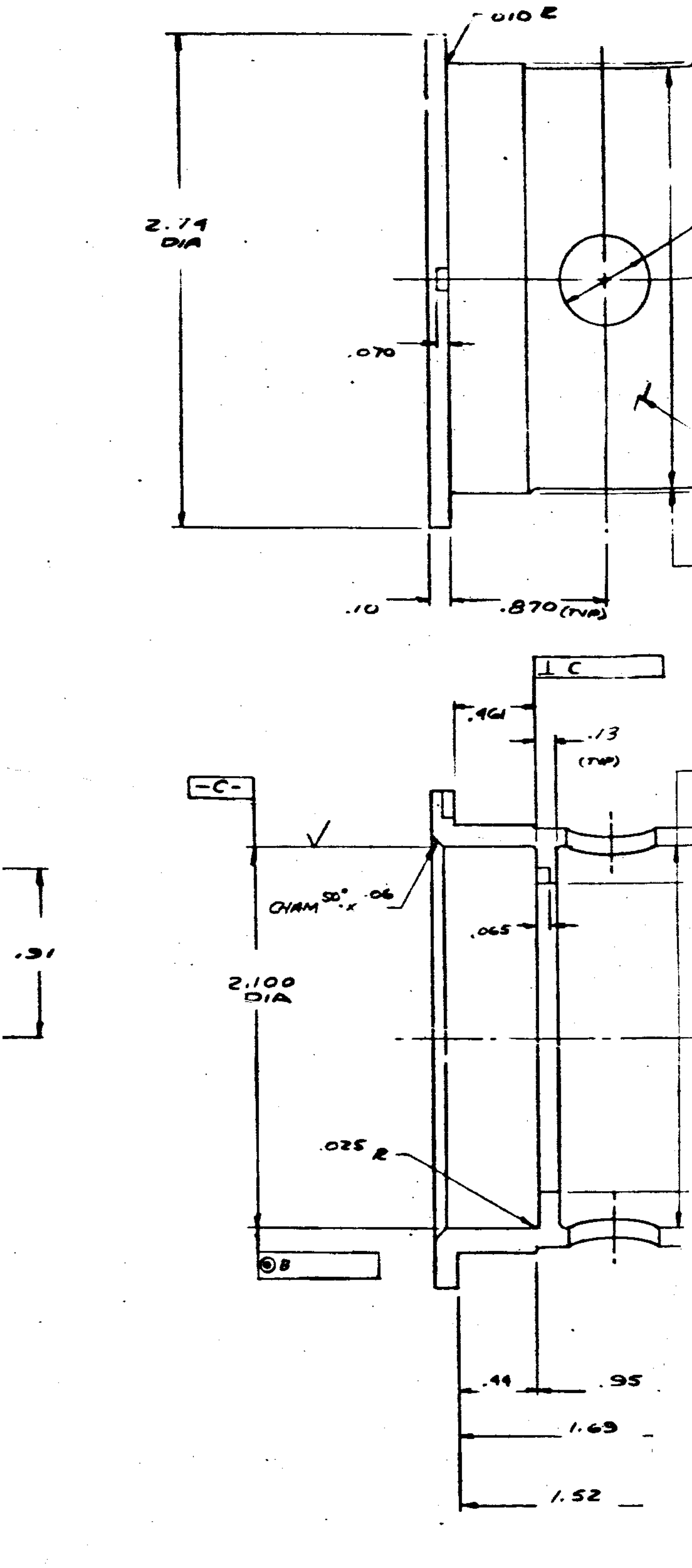
AiResearch Manufacturing Company of Arizona

DWG. TITLE: CARRIER, BEARING

CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369735

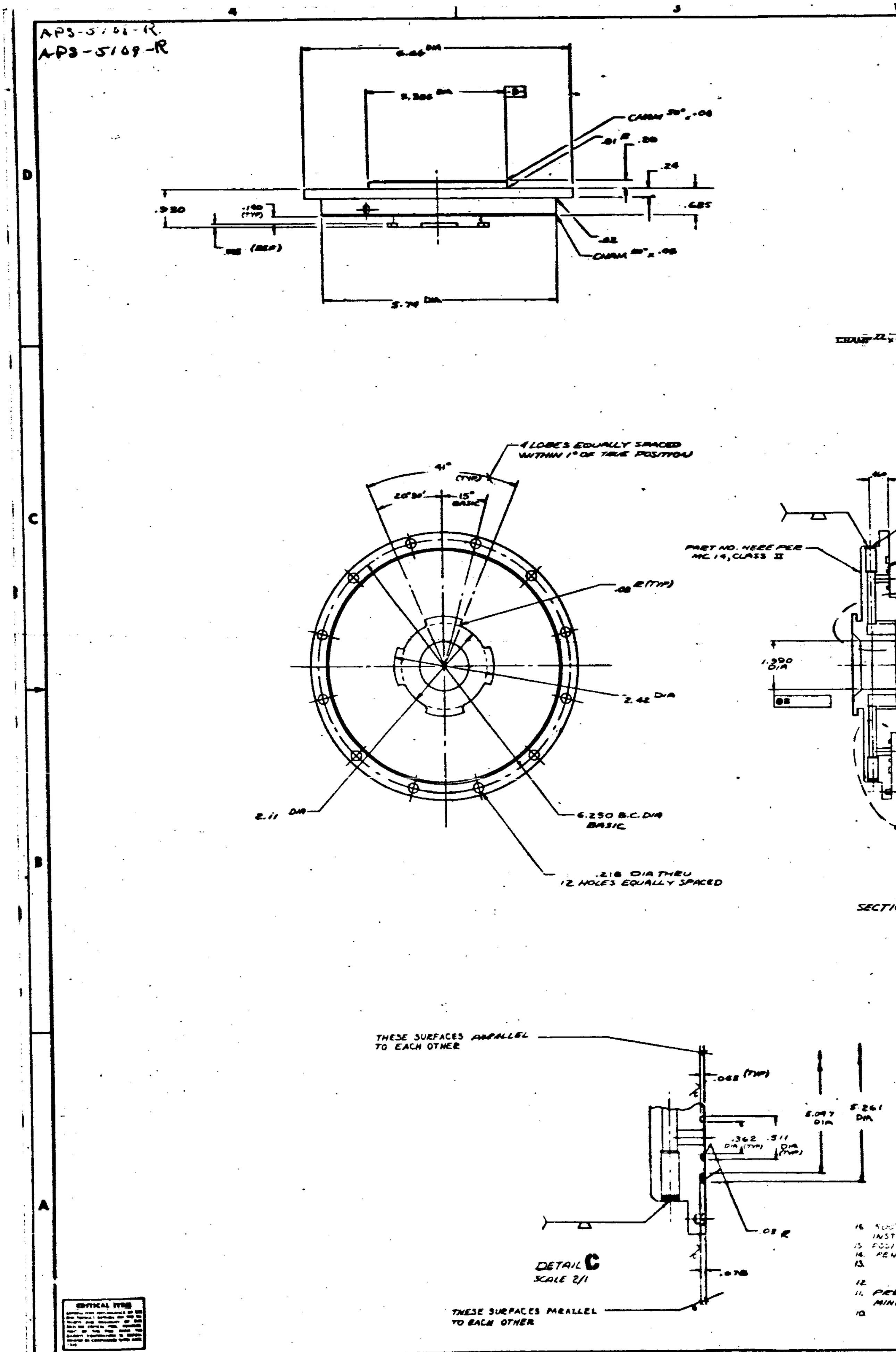
SCALE 2/1 | WT.

86 4



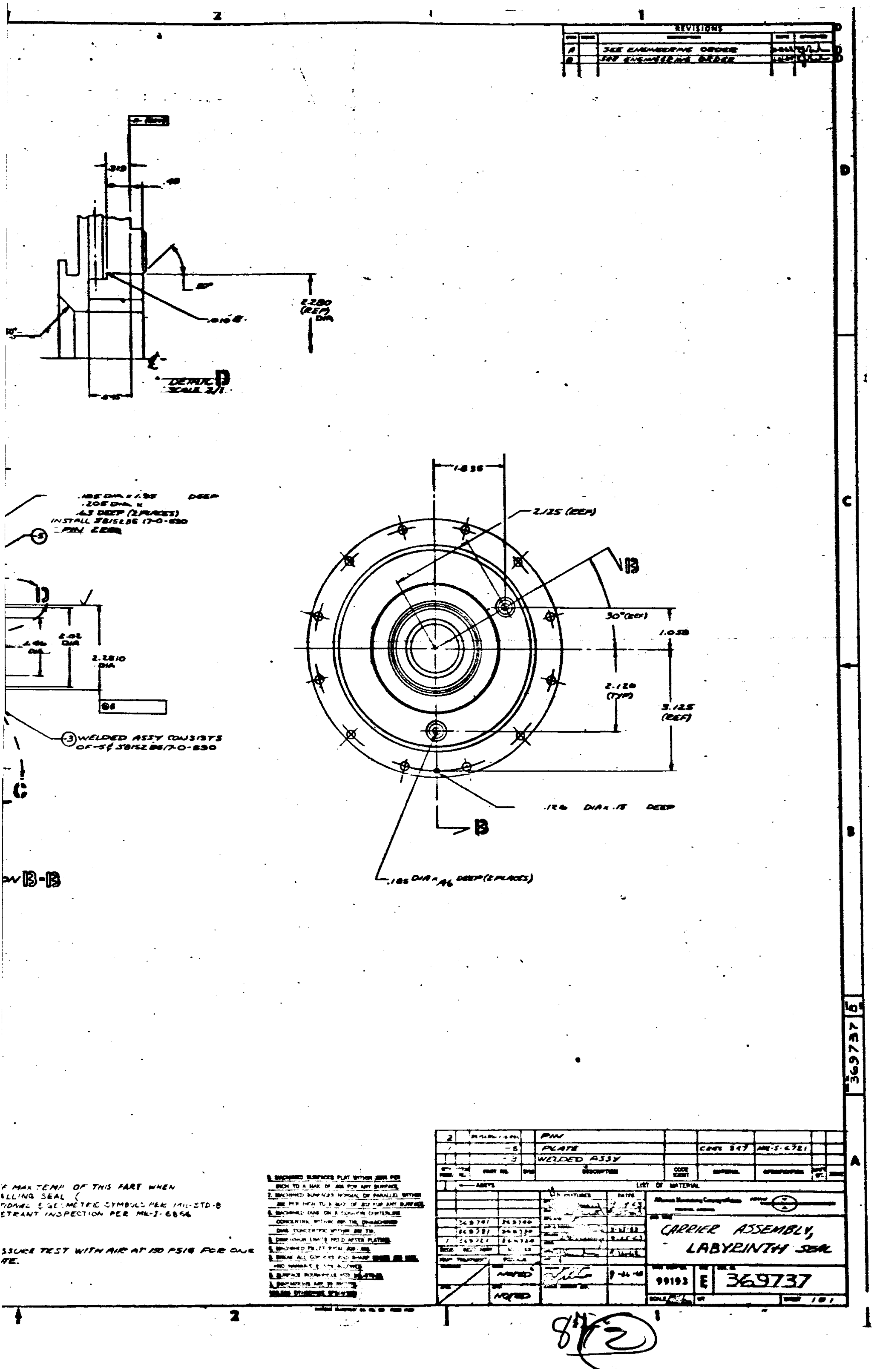
12. POSITIONAL & GEOMETRIC SYMBOLS PER M...
11. SIMILAR TO PA 363572
10. MAGNETIC INSPECTION PER MIL-I-68...

2

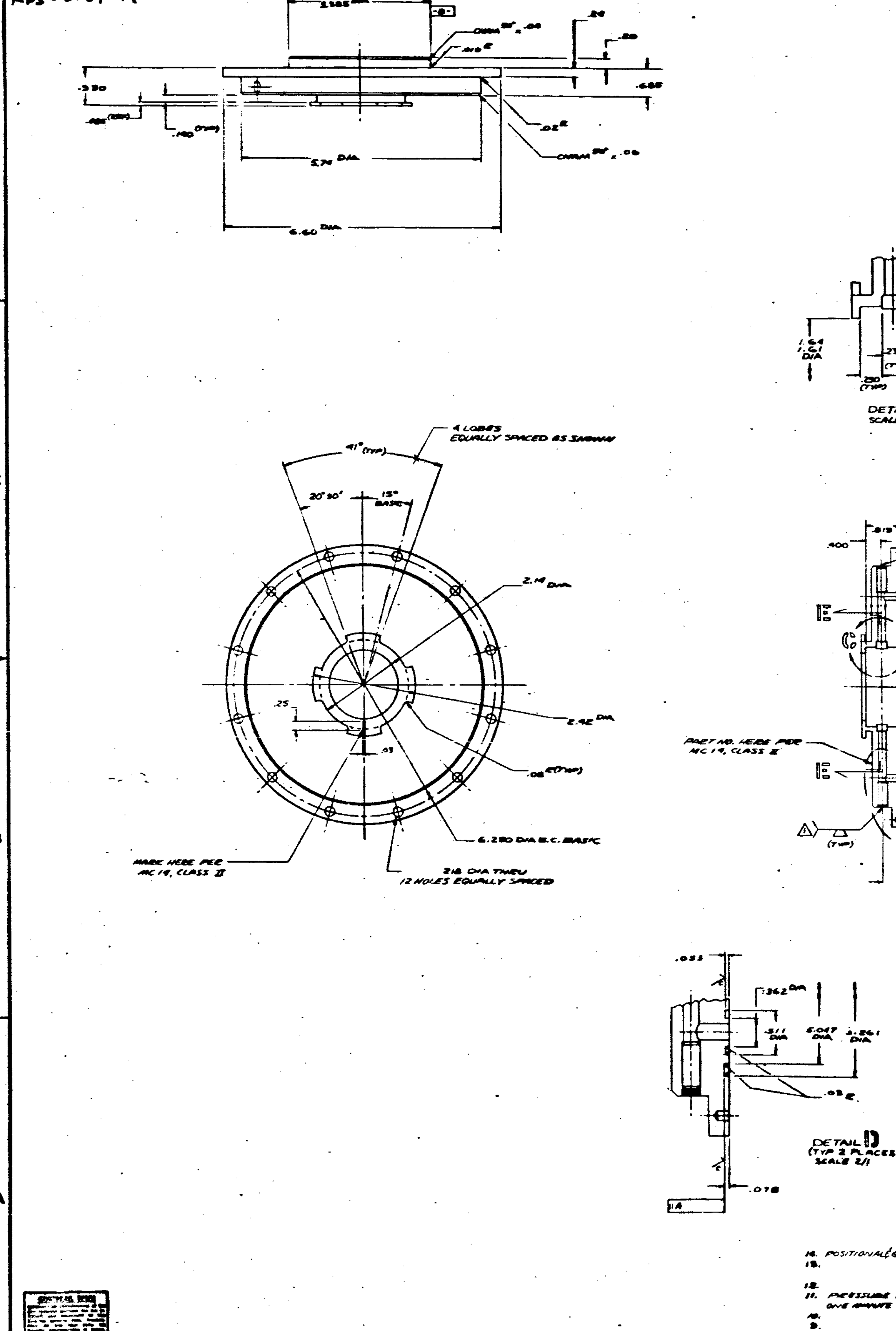


APS-5169-R
5.74 DIA
.685
.24
.330
4 LOBES EQUALLY SPACED WITHIN 1° OF TRUE POSITION
41°
(TYP)
15° BASIC
PART NO. HERE PER MC 14, CLASS II
.08 R (TYP)
2.42 DIA
1.990 DIA
2.11 DIA
6.250 B.C. DIA BASIC
.218 DIA THRU 12 HOLES EQUALLY SPACED
SECTI
THESE SURFACES PARALLEL TO EACH OTHER
.062 (TYP)
5.097 DIA
5.261 DIA
.362 DIA (TYP)
.511 DIA (TYP)
.03 R
DETAIL C
SCALE 2/1
.078
THESE SURFACES PARALLEL TO EACH OTHER

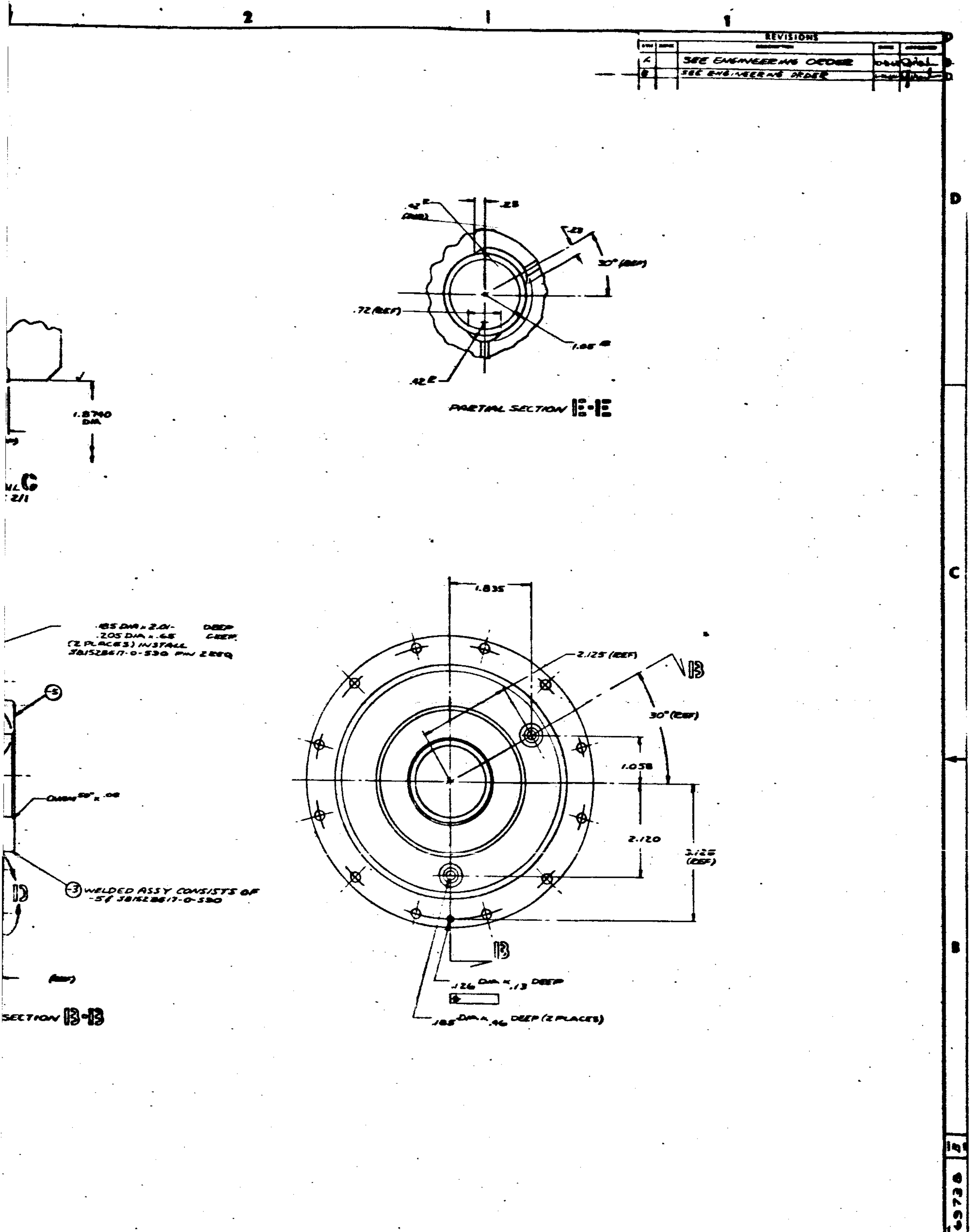
870


REVISIONS
SEE ENGINEERING ORDER
SEE ENGINEERING ORDER
DETAIL D
SCALE 2/1
2.280
(REF)
DIA
.185 DIA x 1.95 DEEP
.205 DIA x
.63 DEEP (2 PLACES)
INSTALL 5815286 17-0-530
PIN
2.02
DIA
2.2810
DIA
WELDED ASSY CONSISTS
OF -5 & 5815286 17-0-530
VIEW B-B
1.835
2.125 (REF)
30° (REF)
1.058
2.120
(TYP)
3.125
(REF)
.126 DIA x .15 DEEP
.185 DIA x .46 DEEP (2 PLACES)
MAX TEMP OF THIS PART WHEN
ALLING SEAL (
TIONAL & GEOMETRIC SYMBOLS PER MIL-STD-8
ETRANT INSPECTION PER MIL-I-6866
SSURE TEST WITH AIR AT 150 PSIG FOR ONE
TE.
2 PIN
-5 PLATE COND 347 MIL-S-6721
-3 WELDED ASSY
LIST OF MATERIAL
CARRIER ASSEMBLY,
LABYRINTH SEAL
99193 E 369737
369737
8(2)

APS-5108-R
APS-5109-R



88 (1)



QTY REQD	ITEM NO	PART NO.		DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION
2		38152B617-0-530		PIN			
1		-5		PLATE		CRES 347	MIL-S-6721
1		-3		WELDED ASSY			

LIST OF MATERIAL

		369740
		369739
1	369753	369729
REQD	NEXT ASSY	USED ON

HEAT TREATMENT: NOTED
PROCESS: NOTED

Dates: 9-25-63, 9-27-63, 9-27-63, 9-27-63, 9-27-63, 9-11-63

CARRIER ASSEMBLY, CARBON SEAL

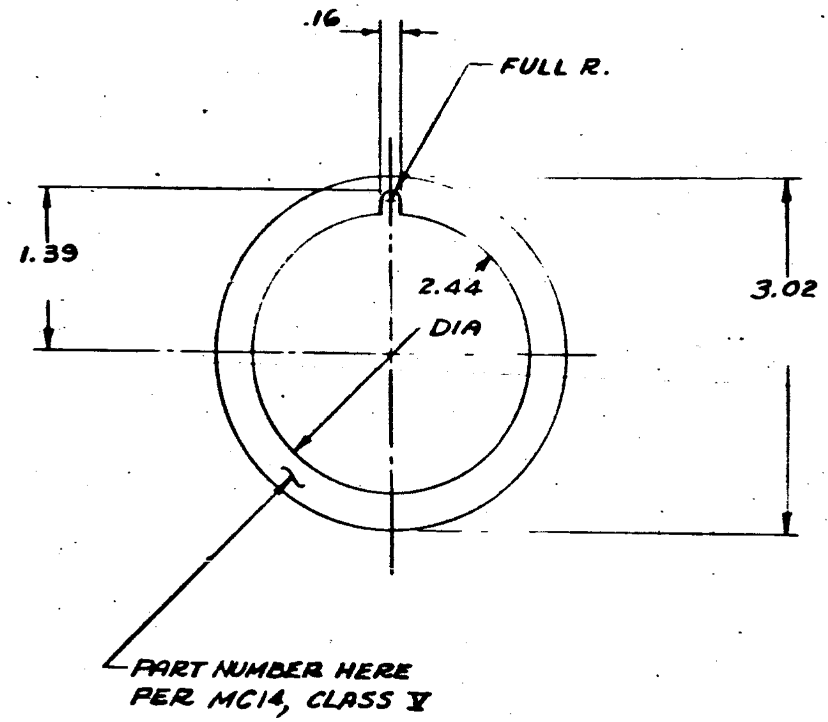
99193 | E | 369738

SCALE FULL — SHEET 1 OF 1

8 8 6

PART NUMBER	T
369743-1	.013 - .011
369743-2	.004 - .002
369743-3	007-.005

APS-5168-R
APS-5169-R

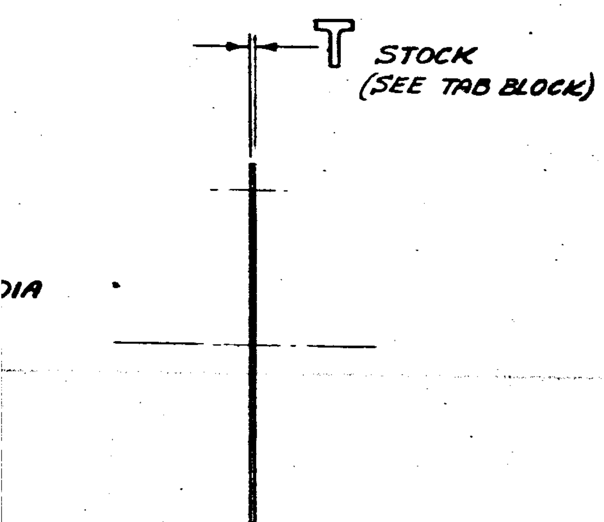


11. REMOVE BURRS.
10. MUST BE FREE FROM WRINKLES.
9. SHARP EDGES PERMISSIBLE.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

SYM	REVISIONS DESCRIPTION	DATE	APPROVED



LAST LTR. —

DWG. NO. 369743

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
		SEE TAB.		SHEET		CRES	MIL-S-6721	

← ASSYS LIST OF MATERIAL

MOD.	NEXT ASSY.	USED ON
	369741	369740
3	369731	369730
2)	369721	369720
1)	369721	369720

HEAT TREATMENT | PROCESS

	SIGNATURES	DATES
DFT	Ed. L. Bell	9-26-63
CHK	Crawford	9-28-63
MFG. ENG.		
MAT. & PROCESS		
STRESS		
AERO		
APP	D. Pranton	9-30-63
APP		
DESIGN ACTIVITY APP.	Williams	9-30-63
OTHER ACTIVITY APP.		

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SHIM,
BEARING CARRIER

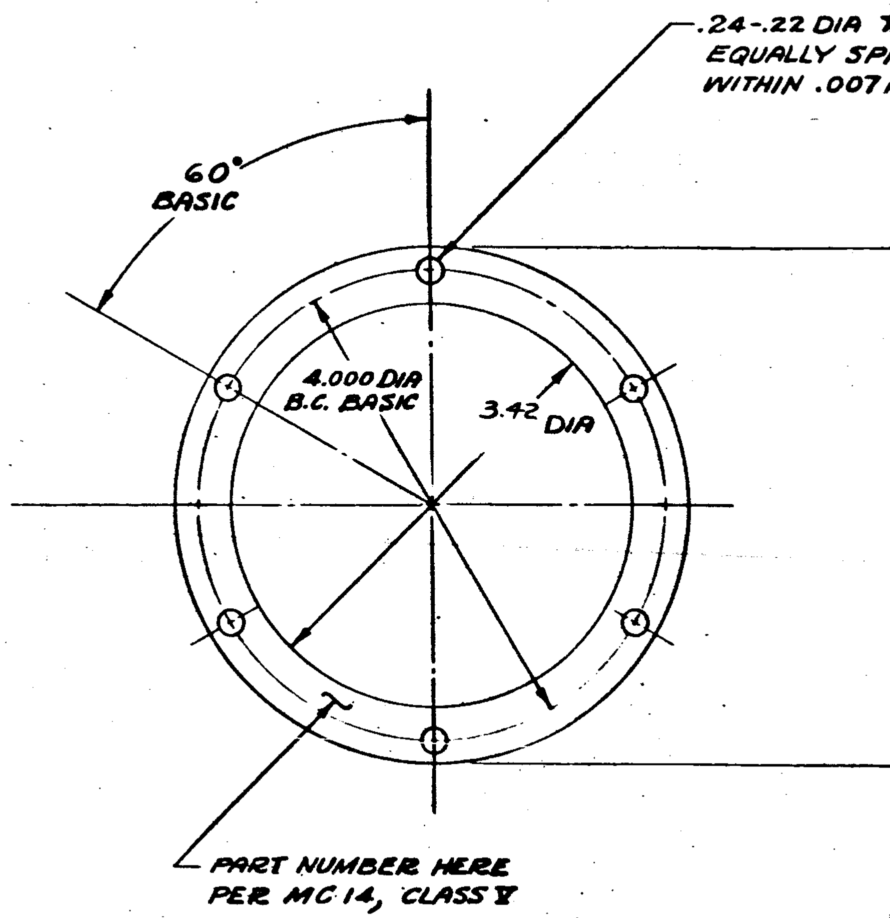
CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369743

SCALE FULL | WT. | SHEET 1 OF 1

89 ②

PART NUMBER	T
369744-1	.013-.011
369744-2	.026-.024
369744-3	.007-.005

APS-5108-R
APS-5109-R



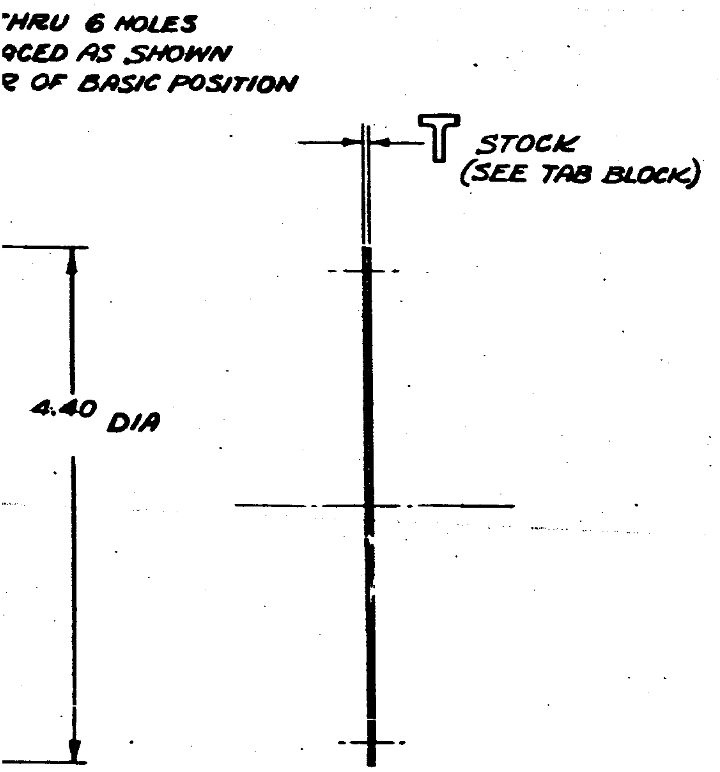
11. ~~REMOVE~~ BURRS.
10. MUST BE FREE FROM WRINKLES.
9. SHARP EDGES PERMISSIBLE.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

90C

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A	SEE ENGINEERING ORDER	1-14-64	[illegible]



QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
		SEE TAB.		SHEET		CRES	MIL-S-6721	

← ASSYS LIST OF MATERIAL

SIGNATURES	DATES
DFT. [illegible]	9-26-63
CHK. [illegible]	9-28-63
MFG. ENG.	
MAT. & PROCESS	
STRESS	
AERO	
APP. [illegible]	9-30-63
APP.	
[illegible]	9-28-63

NEXT ASSY. | USED ON

HEAT TREATMENT | PROCESS

AiResearch Manufacturing Company of Arizona

DWG. TITLE: SHIM, SEAL

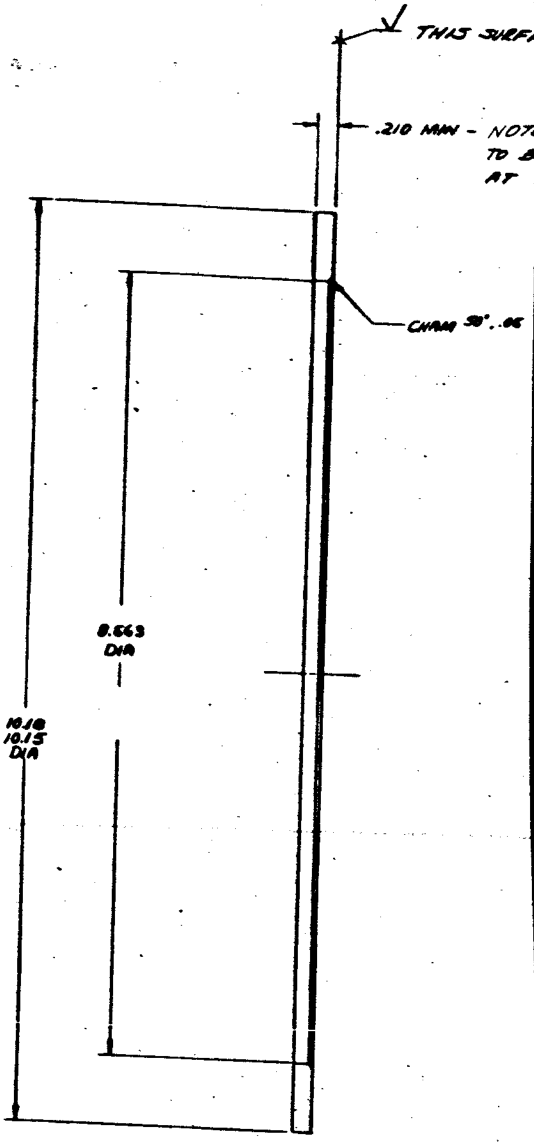
CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369744

SCALE FULL | WT. | SHEET 1 OF 1

DWG. NO. 369744 LAST LTR. A

90 (2)

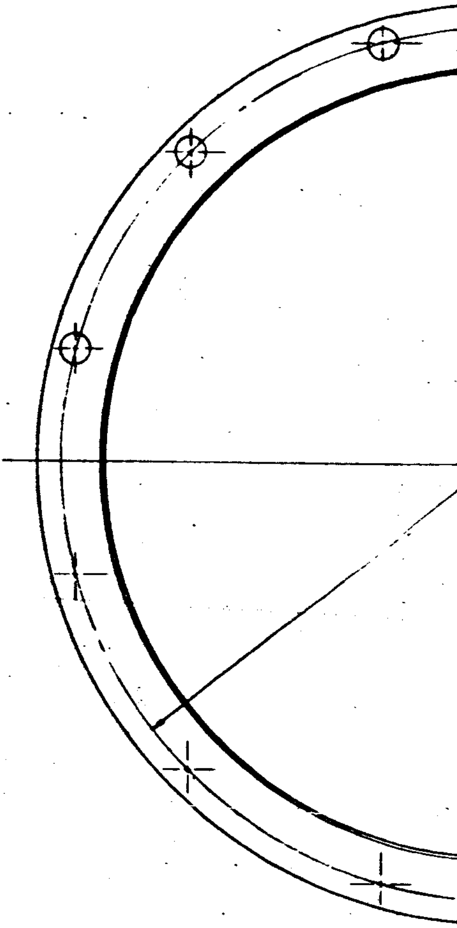
APS-5108-R
APS-5109-R



910

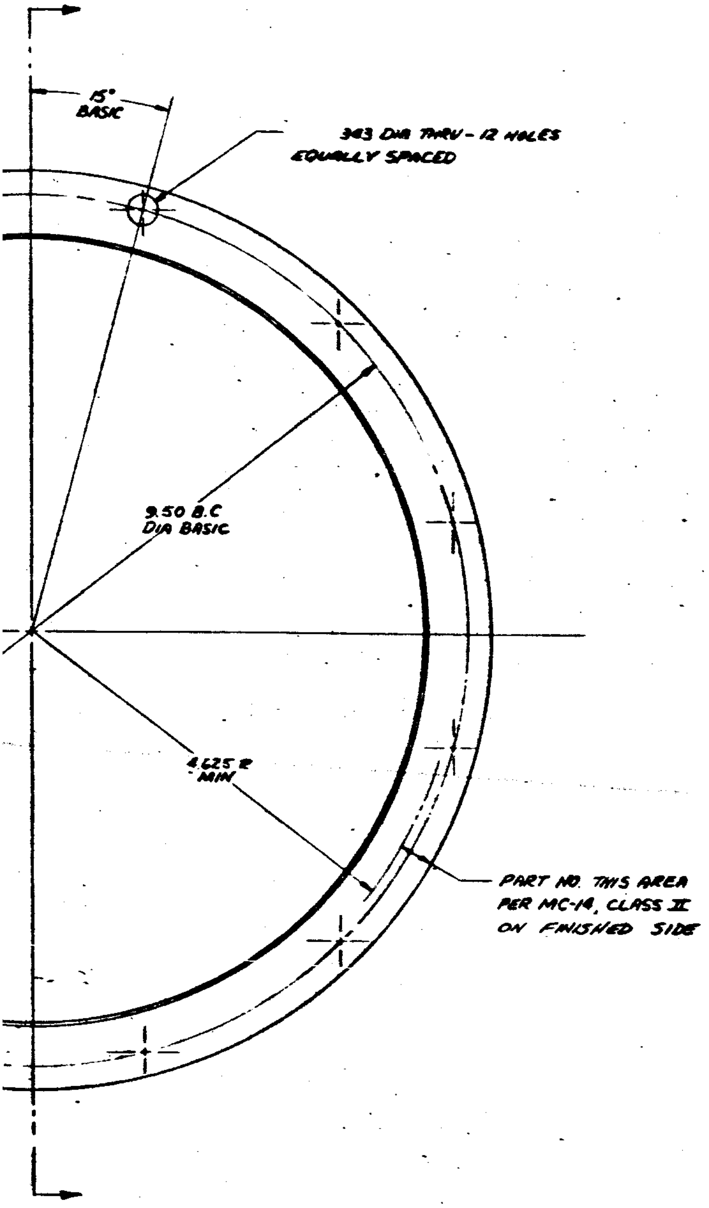
CE FLAT

E: FINAL THICKNESS
E ESTABLISHED
ASSEMBLY



9. MAGNETIC PARTICLE INSPECT PER MIL-I-6868

2



8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITH-IN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY. REQD.	ITEM NO.	PART NO.
	←ASSYS	

REQD.	NEXT ASSY.	USED ON
	369741	369740
	369731	369730
1	369721	369720

HEAT TREATMENT	PROCESS
HARDNESS ROCK "C" 40-34	NAME
SPEC. MIL-H-6875	SPEC.

3

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
1	SEE ENGINEERING ORDER	10-11-63	

D

369745

SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
			STEEL		

LIST OF MATERIAL

SIGNATURES	DATES
DFT.	9-30-63
CHK. Crawford	10-3-63
MFG. ENG.	
MAT. & PROCESS	10-8-63
STRESS	10-5-63
ASSO	
APP	10-4-63
APP	
DESIGN ACTIVITY APP.	10-9-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SHIM - SEALING SPACER

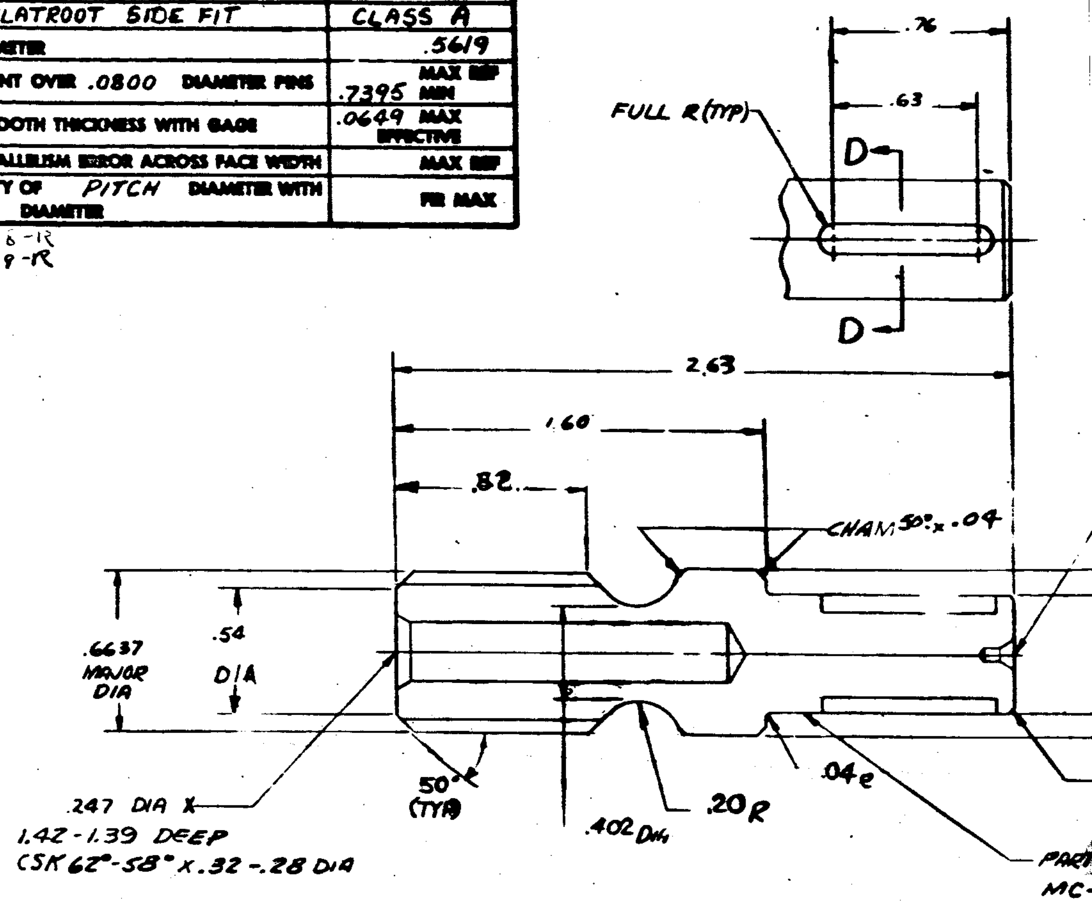
CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369745

SCALE FULL | WT. | SHEET 1 OF 1

9/?4

[illegible] SPLINE DATA	R.C.W. 10-2-63
ASA B5.15 —1960 STANDARD INVOLUTE	15 TEETH
DIAMETRAL PITCH	24 / 48
PRESSURE ANGLE	30°
TYPE - FLATROOT SIDE FIT	CLASS A
MINOR DIAMETER	.5619
MEASUREMENT OVER .0800 DIAMETER PINS	MAX REF .7395 MIN
CIRCULAR TOOTH THICKNESS WITH GAGE	.0649 MAX EFFECTIVE
TOOTH PARALLELISM ERROR ACROSS FACE WIDTH	MAX REF
ECCENTRICITY OF PITCH DIAMETER WITH AXIS OF ℄ DIAMETER	FIR MAX

APS-5708-R
APS-5709-R



SECTION B-B

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

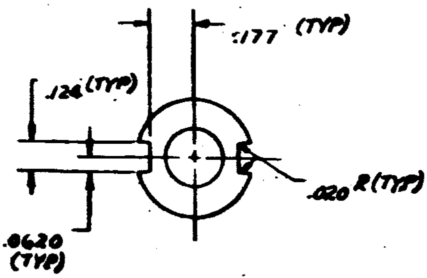
16. ALTERNATE MATERIAL PER MIL-S-5000. HEAT TREAT PER MIL-H-6875 TO ROCK "C" 34-36
15.
14.
13. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866.
12.
11. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8.
10. FINISH SPLINE TOOTH PROFILES √
9.
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD BEFORE PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

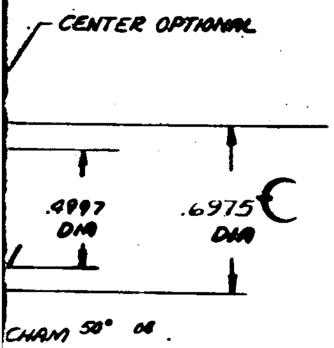
P5949 - SIMS - R & E 143 HERCULENE

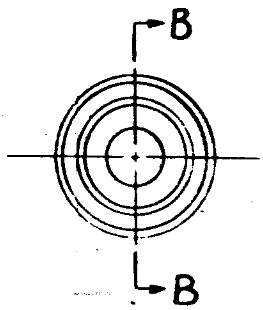
920

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
A2	SEE ENGINEERING ORDER	11/5/63	



SECTION D-D





LAST A

DWG NO. 369746

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						STEEL		

←ASSYS

LIST OF MATERIAL

REQD.	NEXT ASSY.	USED ON
1	369731	369730
1	369721	369720

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

SIGNATURES		DATES
DFT.	R Steyner	10-1-63
CHK.		10-3-63
MFG. ENG		
MAT. & PROCESS		10-9-63
STRESS		10-6-63
AERO		
APP.		10-7-63
APP.		
DESIGN ACTIVITY APP.		10-9-63
OTHER ACTIVITY APP.		

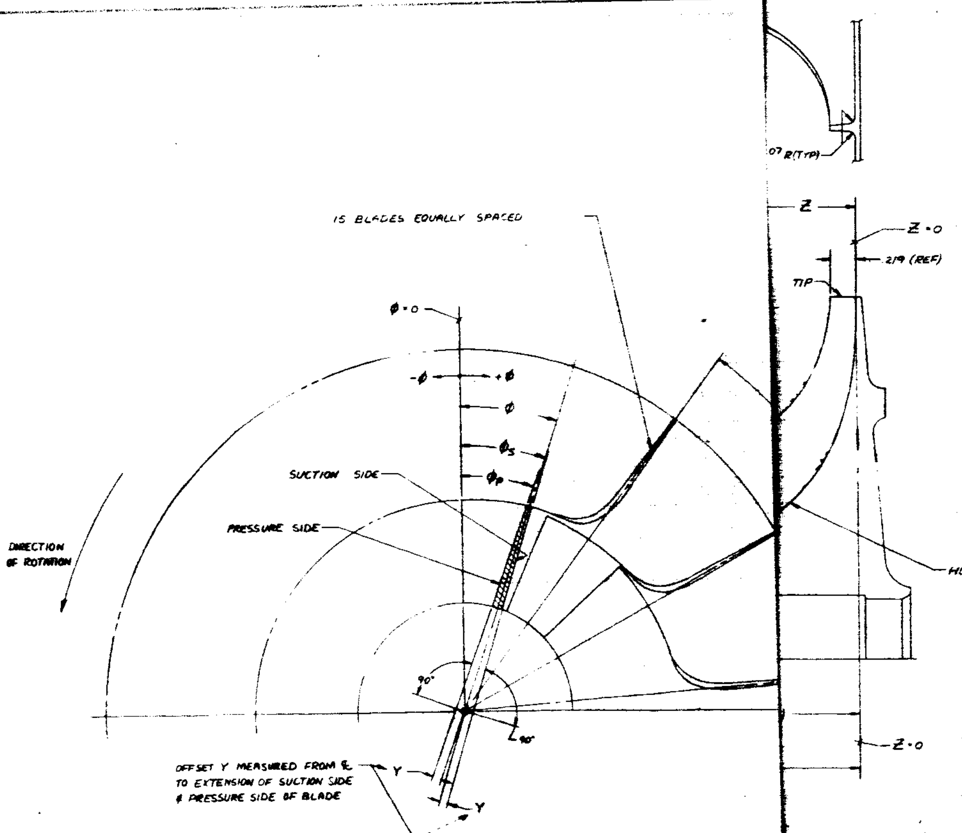
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE: SHAFT, QUILL

CODE IDENT NO	SIZE	DWG. NO.
99193	C	369746

SCALE TWICE | WT. | SHEET 1 OF 1

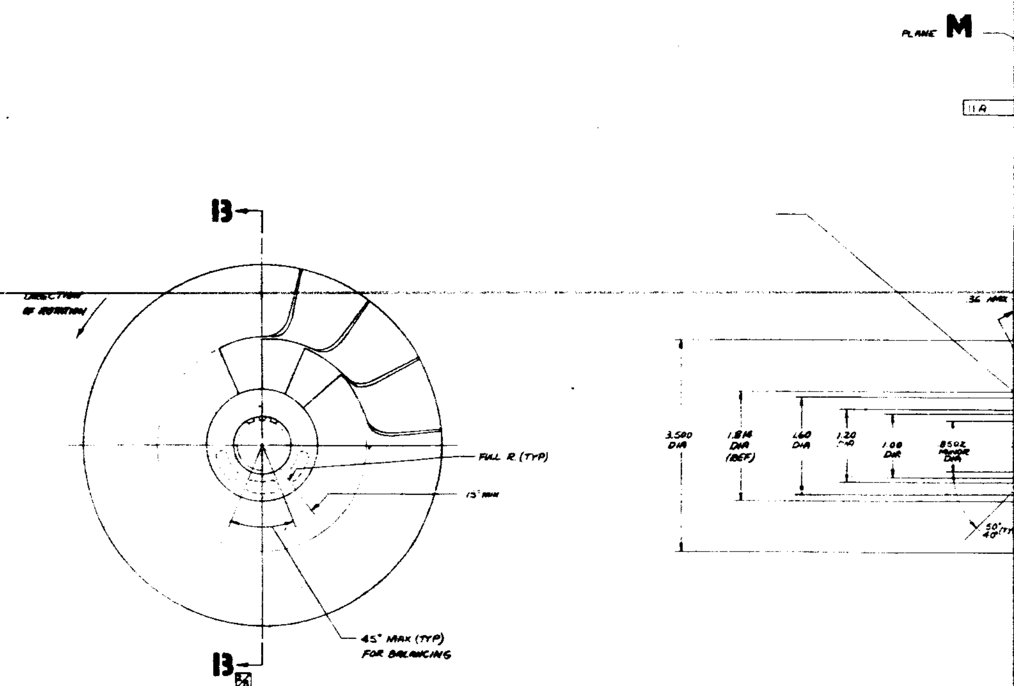
92 (2)


.07 R(TYP)
15 BLADES EQUALLY SPACED
Z
Z = 0
.219 (REF)
TIP
φ = 0
-φ
+φ
φ
φS
φP
SUCTION SIDE
PRESSURE SIDE
DIRECTION OF ROTATION
HUB
90°
90°
OFFSET Y MEASURED FROM ℄ TO EXTENSION OF SUCTION SIDE & PRESSURE SIDE OF BLADE
Y
Y
Z = 0

93①

93②

[illegible]
[illegible]
[illegible]
[illegible]
TYPE - FLAT ROOT SIDE FIT
[illegible]
[illegible] .0864 [illegible]
[illegible]
[illegible]
[illegible] PITCH [illegible] ¢ [illegible]
TRUE INVOLUTE FORM DIA



16

93 (3)

15

14\. FLASH COPPER PLATE SPLINE

13

12\. POSITIONAL AND GEOMETRIC TOLERANCE SY
PER MIL-STD-8.

11\. FINISH SPLINE TOOTH PROFILES √

10\. FINISH ALL OVER √ EXCEPT BLADE & BLA

9\. **A** SURFACE AND ¢ DIA ESTABLISH

20\. THE COMPLETE SERIAL NO. SHALL BE TRANSFERRED FROM FORGING AND RETAINED ON PART THROUGH-OUT LIFE OF THE PART

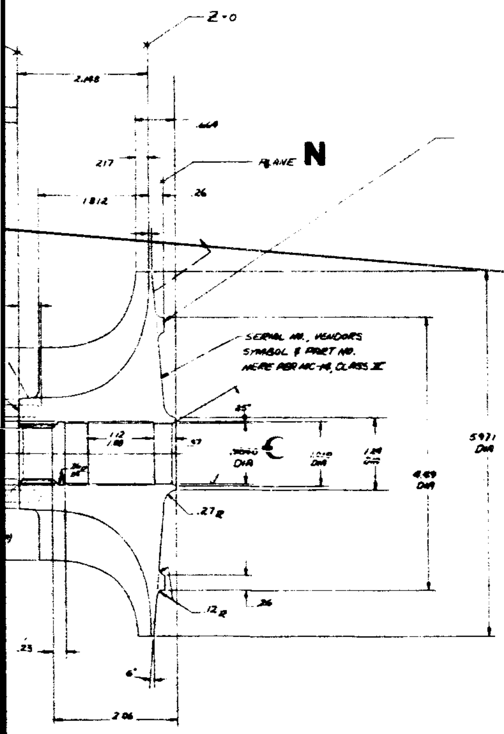
19\. SHOT PEEN ENTIRE AREA ENCLOSED THUS (←-----→) PER AMS 2430 USING .021-.018 DIA STEEL SHOT TO AN INTENSITY OF .006-.004 ALMEN A2

18\. TYPE I PENETRANT INSPECT PER MIL-I-6866 USING ZL-2 PENETREX

17\. BLADE SHAPE TO FAIR SMOOTHLY BETWEEN POINTS DIMENSIONED IN TABLES.-

16 TEETH	
30/40	
30°	
.960 - .950	
.7793 MAX	
.0785 MIN EFFECTIVE	
.0003 MAX	
.0015 TIR MAX	
.940 MIN	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED



SECTION B B

§ 3 (4)

...MBOLS

...E PASSAGES √

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .002 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .002 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .002 TIR. UNMACHINED DIAS. CONCENTRIC WITHIN .030 TIR.
5. DIMENSION LIMITS APPLY BEFORE PLATING.
4. UNDIMENSIONED FILLET RADII .010 - .030.
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANDLING MARKS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

QTY REQD	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.	ZONE
		-3		FORGING		TITANIUM	EMS491		
←ASSYS				LIST OF MATERIAL					

REQD	NEXT ASSY	USED ON
1	369731	369730

HEAT TREATMENT	PROCESS
	NOTED
	NOTED

SIGNATURES	DATES
	10-8-63
	10-18-63
	10-18-63
	10-18-63
R C	10-18-63
	10-18-63
	10-21-63

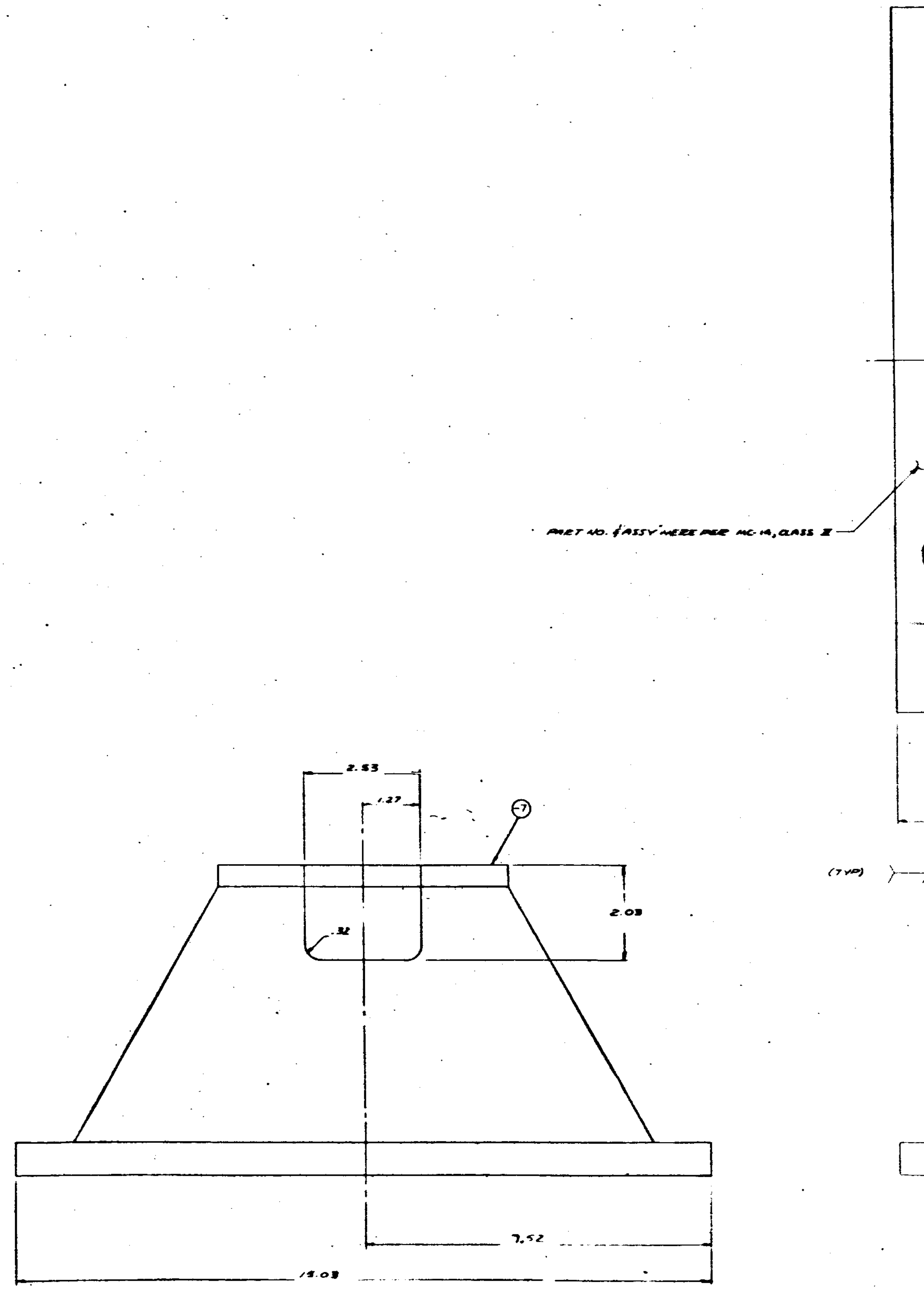
IMPELLER, COMPRESSOR

CODE IDENT NO.	SIZE	DWG. NO.
99193	J	369747

SCALE FULL | WT 24 LB CALC. | SHEET 1 OF 1

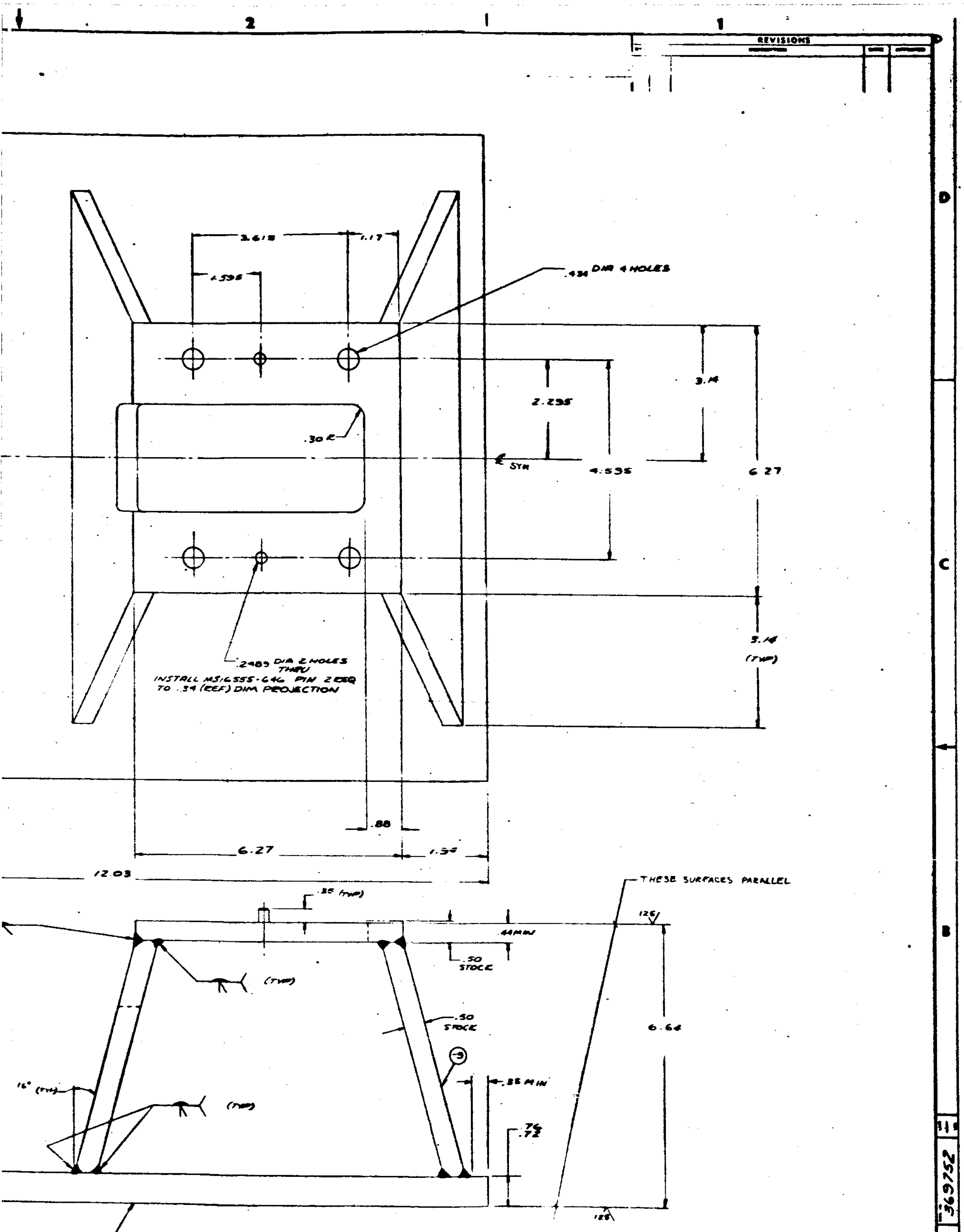
369747

APS-5108-R
APS-5109-R



CRITICAL ITEM

94 ①



2				MS16555-646 PIN					
2		-9					347	MIL-S-6721	
1		-7		TOP			347	MIL-S-6721	
1		-6					347	MIL-S-6721	
1		-5							
QTY REQ	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT	ZONE
	ASSY								

LIST OF MATERIAL

8. MACHINED SURFACES FLAT WITHIN .005 PER INCH TO A MAX OF .005 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .010 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTER LINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .010 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .015 .030.
3. BREAK ALL CORNERS AND SHARP EDGES .005 .010. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED

PENETRANT INSPECT WELD PER MIL-I-6866

ASSY TO BE FREE OF WELD SPATTER

DATES

STAND ASSEMBLY
MOUNTING

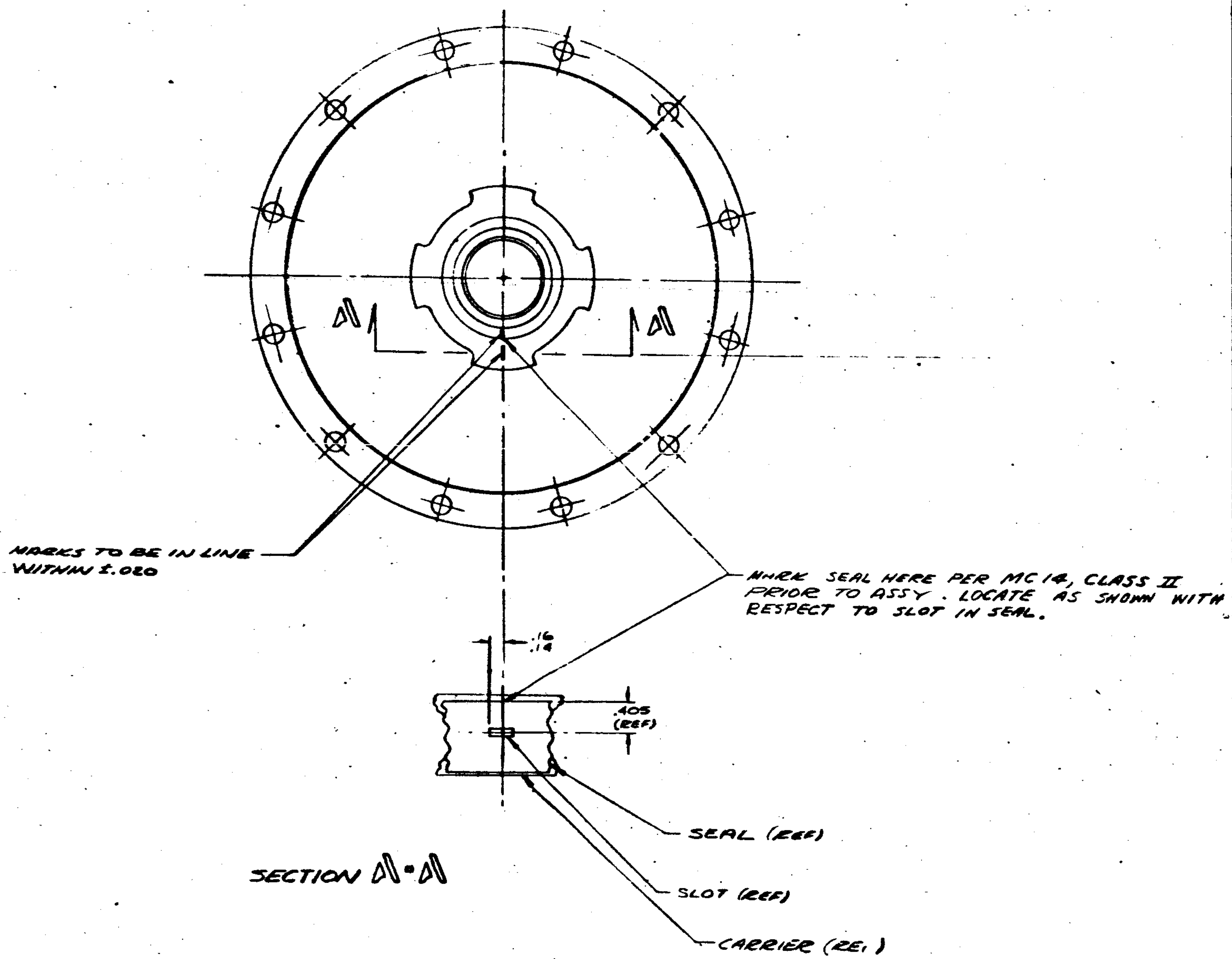
99193 E 369752

SCALE

SHEET 1 OF

94 ②

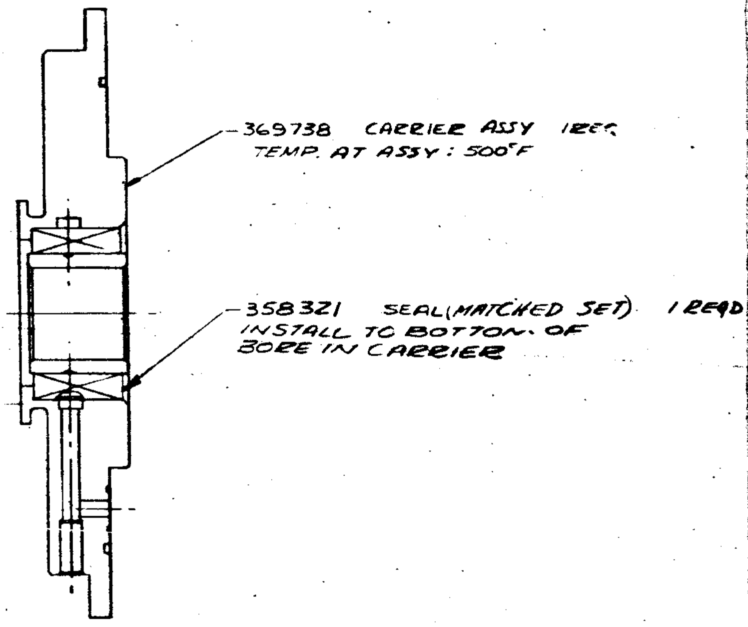
APS-5108-R
APS-5109-R.



SECTION A-A

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.



8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY. REQD.	ITEM NO.	PART NO.
	←ASSYS	

REQD	NEXT ASSY.	USED ON
	369741	369740
	369731	369730
1	369721	369720

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

LIST OF MATERIAL

SIGNATURES	DATES
DFT [illegible]	5-11-63
CHK Crawford	10-24-63
MFG. ENG.	
MAT & PROCESS	
STRESS	
AERO	
APP [illegible]	5-15-63
APP	
DESIGN ACTIVITY APP Willson	5-15-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona

DWG. TITLE: SEAL ASSEMBLY, CARBON

CODE IDENT NO: 99193 | SIZE: D | DWG. NO: 369753

SCALE Full | WT | SHEET 1 OF 1

95 2 3

INTERNAL SPLINE DATA R.C. Wright	
ASA B5.5:15—1960 STANDARD INVOLUTE	15 TEETH
DIAMETRAL PITCH	24 / 48
PRESSURE ANGLE	30°
FLAT ROOT - SIDE FIT	
MAJOR DIAMETER	.6790
MEASUREMENT BETWEEN .0600 DIAMETER PINS	.5594 MAX
CIRCULAR SPACE WIDTH WITH GAGE	.0654 MIN EFFECTIVE
TOOTH PARALLELISM ERROR ACROSS FACE WIDTH	MAX REF
ECCENTRICITY OF PITCH DIAMETER WITH AXIS OF B DIAMETERS	FIR MAX

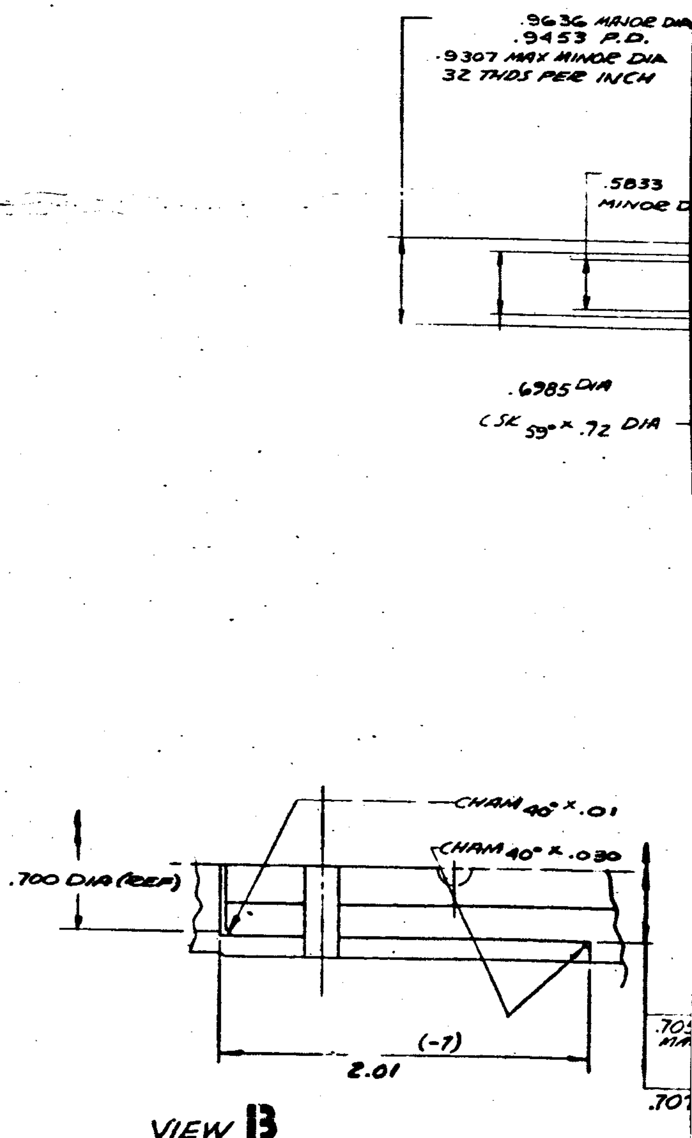
MPS-5.04-R

EXTERNAL
ASA B5.15 —1960 STAN
DIAMETRAL PITCH
PRESSURE ANGLE
TYPE - FLAT RO
MINOR DIAMETER
MEASUREMENT OVER .0
CIRCULAR TOOTH THICKN
TOOTH PARALLELISM ERRO
ECCENTRICITY OF PIT AXIS OF B DIAMETERS
TRUE INVOLUTE

.1870 DIA THRU 2 WALLS. INSTALL MS16555-
FINISH END SIMULTANEOUSLY WITH [-B-] DIA (

3

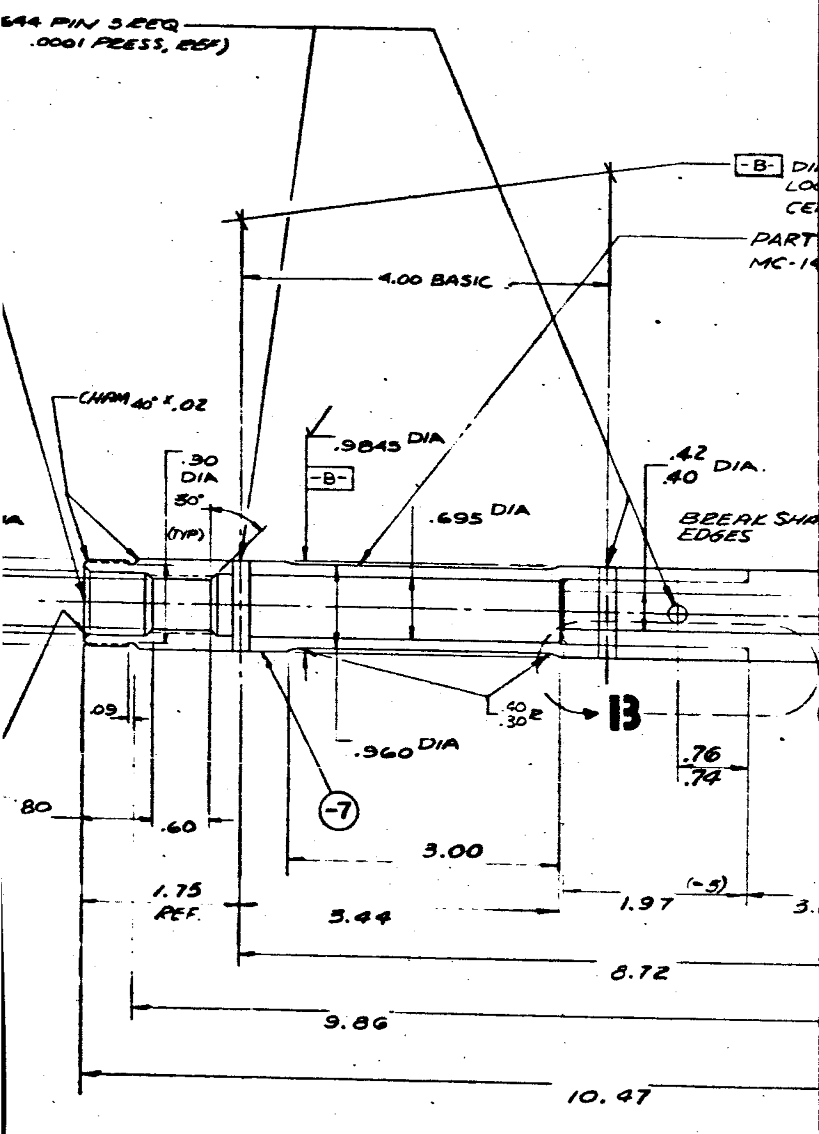
FLASH COPPER PLATE ENTIRE INSIDE OF CAVITY,
& END OF SHAFT - SPLINE DIMENSIONS PRIOR TO PLATING



VIEW B
SCALE 2/1

910

SPLINE DATA	E.C. Wright 11-7-63
DARD INVOLUTE	18 TEETH
	20 / 40
	30°
OT SIDE FIT	CLASS 1
	.826
960 DIAMETER PINS	1.0415 MAX REF MIN
SS WITH GAGE	.0770 MAX EFFECTIVE
R ACROSS FACE WIDTH	MAX REF
CH DIAMETER WITH	FIR MAX
FORM DIA.	.8462 MAX



2 DIA. (-7 SHAFT)
TEMP. 600°F (-7)

2 DIA. (-5 SHAFT)

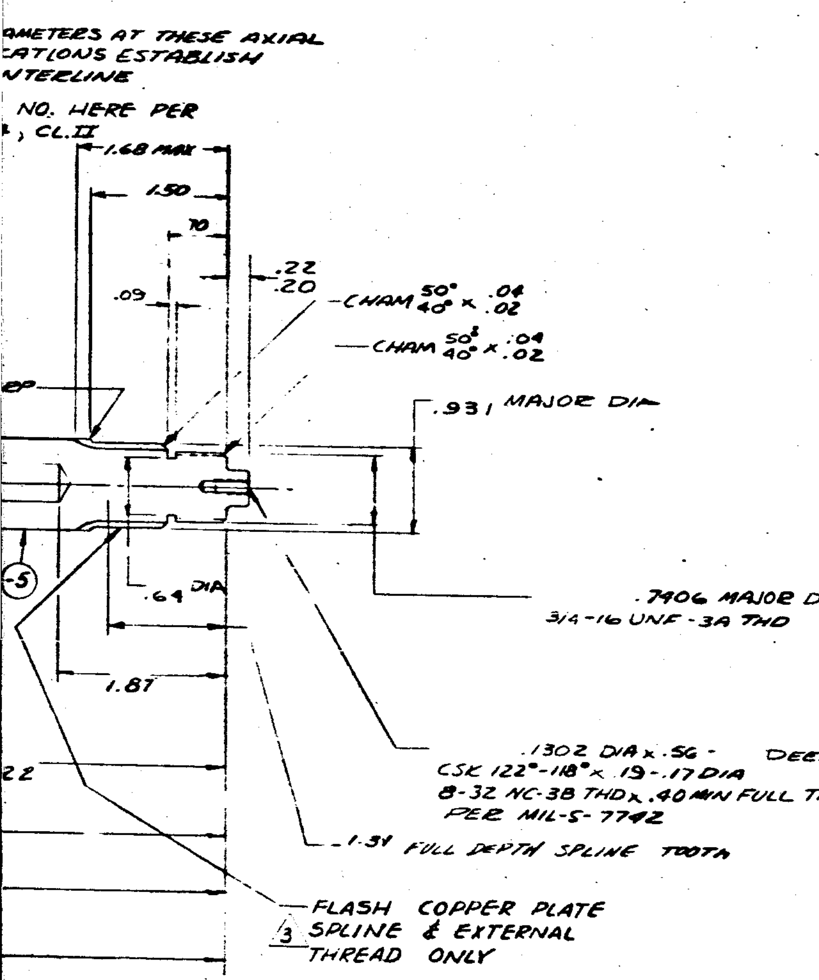
14. POSITIONAL & GEOM. TOL. SYM. PER MIL-STD-8

13.

12. AFTER FINAL MACHINING, PENETRANT INSP PER MIL-I-6866, TYPE I

11. SIMILAR TO 363726

10



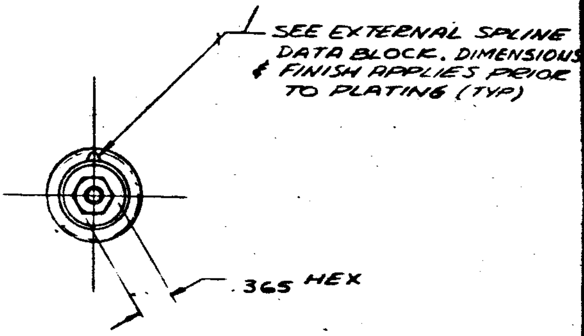
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX OF .002 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX OF .012 FOR ANY SURFACE.
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .002 T.I.R. UNMACHINED DIAS. CONCENTRIC WITHIN .032 T.I.R.
5. ~~DIMENSIONS APPLY AFTER PLATING~~
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

ECT

		-7	
		-5	
QTY. REQD.	ITEM NO.	PART NO.	SYM
	←ASSYS		
1	369731	369730	
REQD.	NEXT ASSY.	USED ON	
HEAT TREATMENT		PROCESS	
MACHINED		NOTED	
SPEC.		NOTED	

3

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



A

D

CRITICAL ITEM
SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
SHAFT		STEEL 4340		
SHAFT		STEEL 4340		

LIST OF MATERIAL

SIGNATURES	DATES
	10-10-63
	11-7-63
	11-7-63
	11-14-63
ACTIVITY APP.	11-11-63
ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona, PHOENIX, ARIZONA — A DIVISION OF THE GARRETT CORPORATION

DWG. TITLE: SHAFT ASSEMBLY, IMPELLER

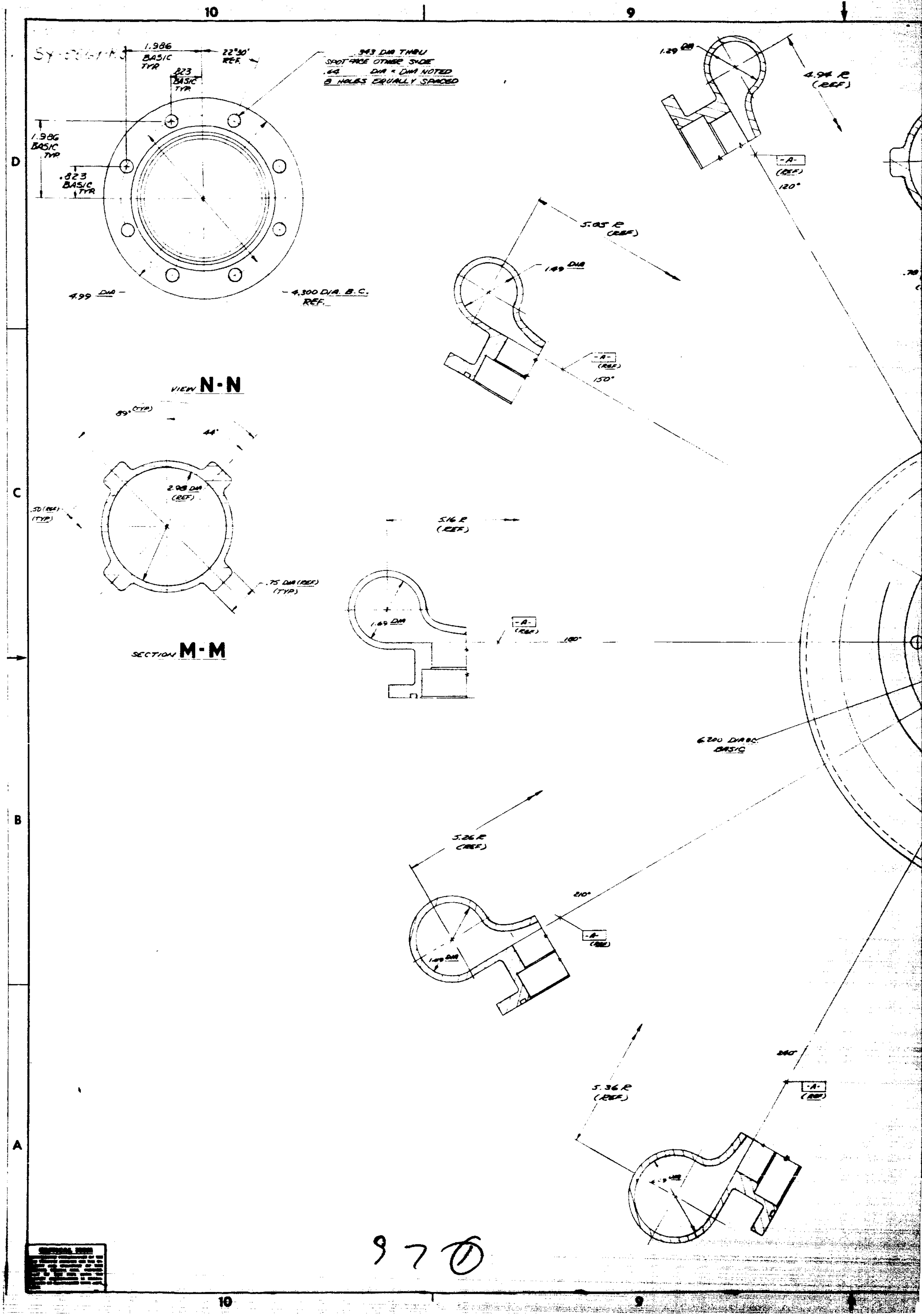
11-15-63

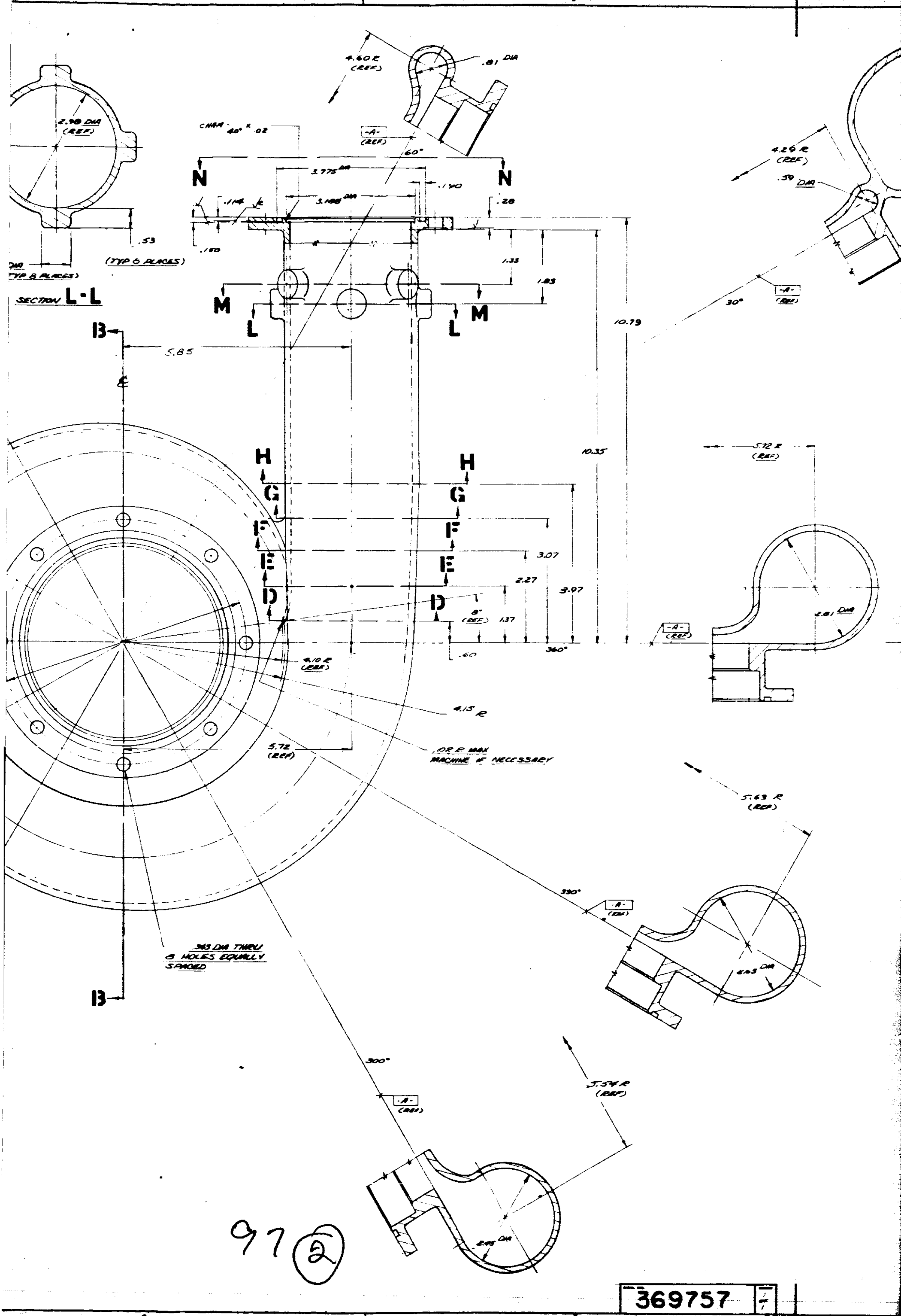
CODE IDENT NO.	SIZE	DWG. NO.
99193	D	369754

SCALE FULL | WT. | SHEET 1 OF 1

DWG. NO. 369754

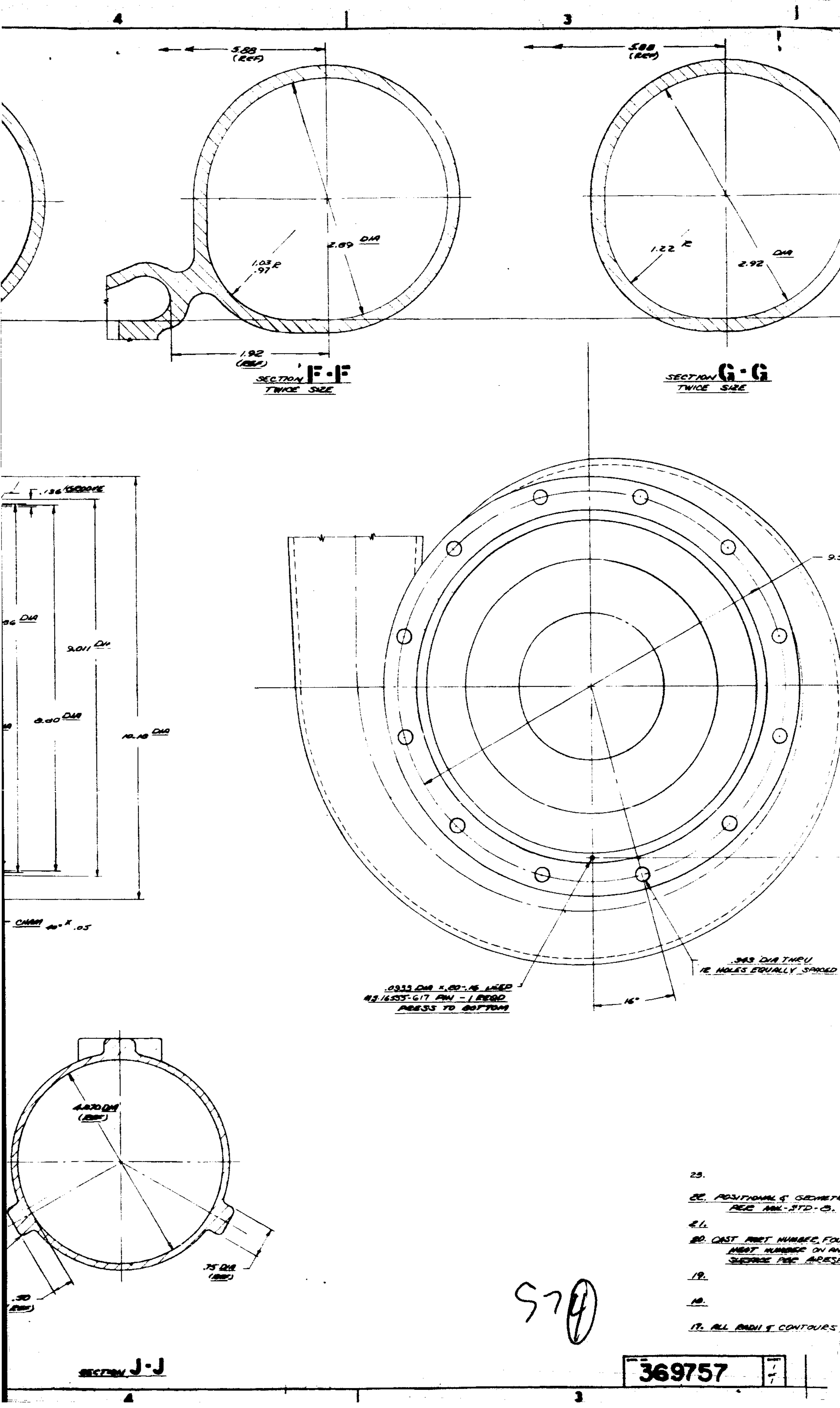
9 6 2 4


10
9
D
C
B
A
1.986 BASIC TYP
22°30' REF.
.823 BASIC TYP.
.343 DIA THRU
SPOT FACE OTHER SIDE
.64 DIA × DIM NOTED
8 HOLES EQUALLY SPACED
1.986 BASIC TYP
.823 BASIC TYP.
4.99 DIA
4.300 DIA. B.C. REF.
VIEW N-N
89° (TYP)
44°
2.98 DIA (REF)
.50 (REF) (TYP)
.75 DIA (REF) (TYP)
SECTION M-M
1.29 DIA
4.94 R (REF)
-A- (REF)
120°
5.05 R (REF)
1.49 DIA
-A- (REF)
150°
5.16 R (REF)
1.69 DIA
-A- (REF)
180°
6.200 DIA B.C. BASIC
5.26 R (REF)
210°
-A- (REF)
240°
5.36 R (REF)
-A- (REF)
970

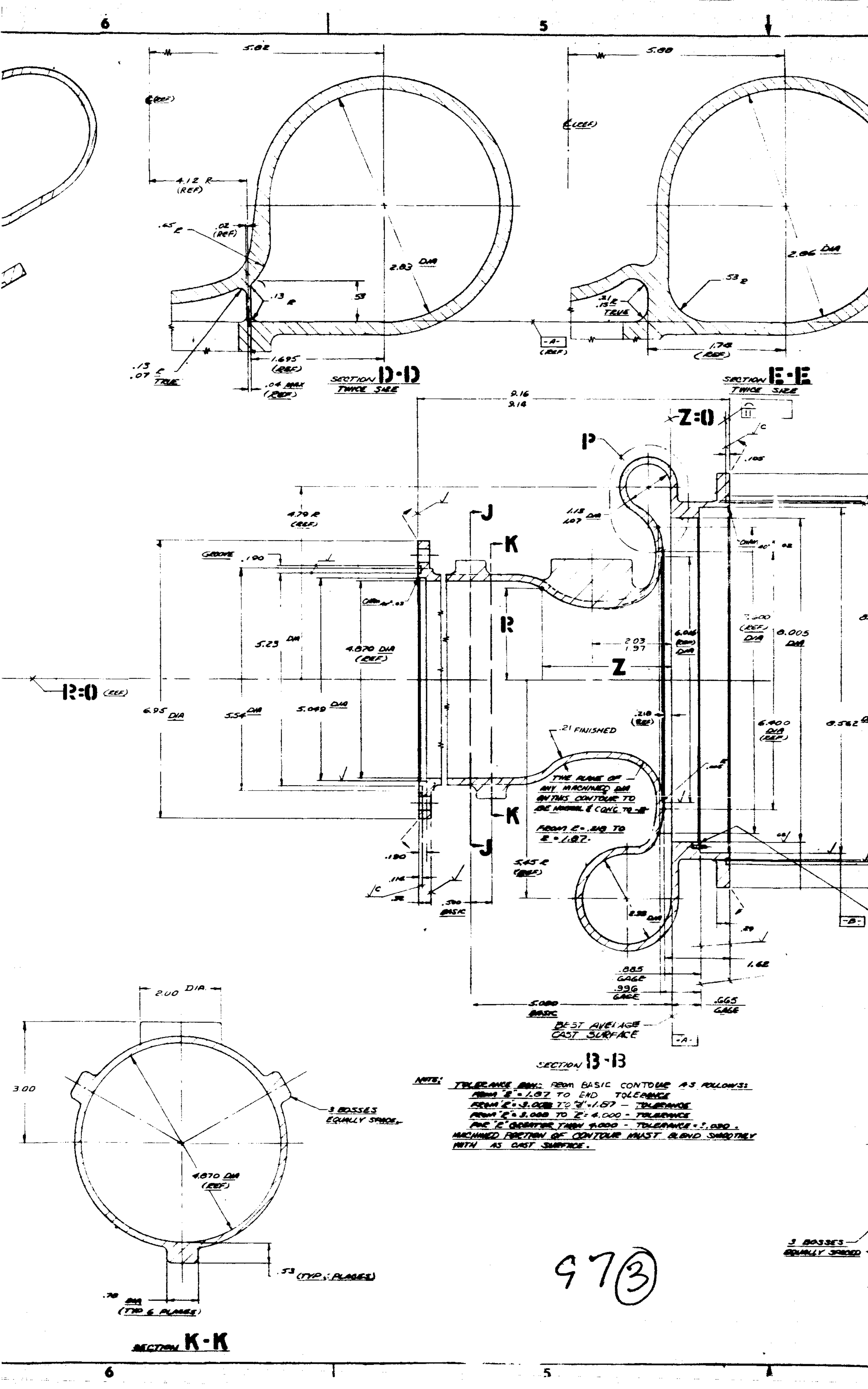


SECTION L-L
(TYP 6 PLACES)
CHAM 40° x .02
3.775 DIA
3.188 DIA
.140
.28
.114
.150
.53
1.35
1.83
10.79
10.35
5.85
4.60 R (REF)
.81 DIA
4.29 R (REF)
.59 DIA
-A- (REF)
60°
30°
5.72 R (REF)
2.81 DIA
3.07
2.27
3.97
1.37
.60
8° (REF)
360°
4.10 R (REF)
4.15 R
5.72 (REF)
.02 R MAX MACHINE IF NECESSARY
5.63 R (REF)
330°
2.63 DIA
300°
5.54 R (REF)
2.45 DIA
.343 DIA THRU 8 HOLES EQUALLY SPACED
97 2

369757



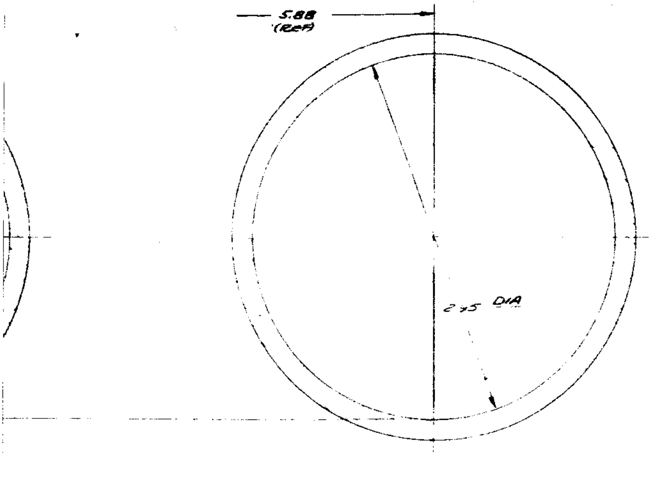
4
3
5.88 (REF)
5.88 (REF)
2.89 DIA
1.03 R .97
1.92 (REF)
SECTION F-F
TWICE SIZE
1.22 R
2.92 DIA
SECTION G-G
TWICE SIZE
.136 GROOVE
9.011 DIA
8.00 DIA
10.18 DIA
.343 DIA THRU
12 HOLES EQUALLY SPACED
.0933 DIA x .80-.16 LIKED
MS 16555-617 PIN - 1 REQD
PRESS TO BOTTOM
16°
4.870 DIA (REF)
.75 DIA (REF)
SECTION J-J
23.
22. POSITIONAL & GEOMET
REF MIL-STD-8.
21.
20. CAST PART NUMBER, FOU
HEAT NUMBER ON AN
19.
18.
17. ALL RADII & CONTOURS
369757



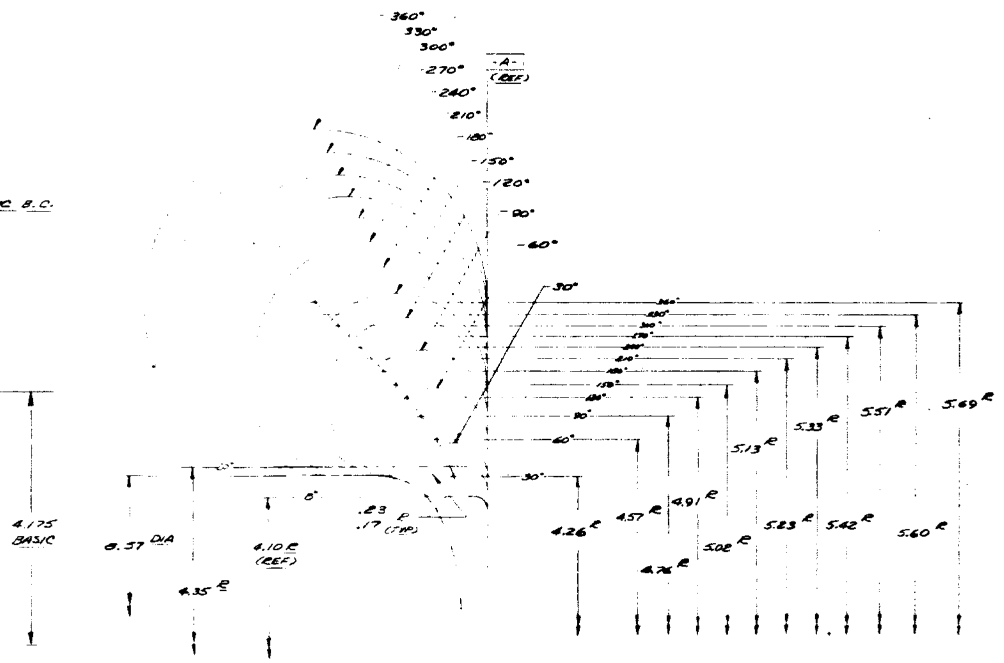
6
5
5.82
℄ (REF)
4.12 R
(REF)
.65 R
.02
(REF)
2.83 DIA
.13 R
.53
.13
.07 R
TRUE
1.695
(REF)
.04 MAX
(REF)
SECTION D-D
TWICE SIZE
5.88
℄ (REF)
2.86 DIA
.53 R
.31 R
.15 R
TRUE
-A-
(REF)
1.78
(REF)
SECTION E-E
TWICE SIZE
9.16
9.14
Z:0
P
.105
4.79 R
(REF)
J
K
1.13
1.07 DIA
GROOVE .190
R
5.23 DIA
4.870 DIA
(REF)
2.03
1.97
Z
6.046
(REF)
DIA
8.005
DIA
R:0 (REF)
6.95 DIA
5.54 DIA
5.049 DIA
.218
(REF)
6.400
DIA
(REF)
8.562
.21 FINISHED
THE PLANE OF ANY MACHINED DIA ON THIS CONTOUR TO BE NORMAL & CONC TO -B-
FROM R = .218 TO R = 1.87.
5.45 R
(REF)
.190
.116
.32
.500
BASIC
2.38 DIA
-B-
.29
1.62
.885
GAGE
.996
GAGE
5.080
BASIC
.665
GAGE
BEST AVERAGE CAST SURFACE
-A-
SECTION B-B
NOTE: TOLERANCE BAND FROM BASIC CONTOUR AS FOLLOWS:
FROM "Z" = 1.87 TO END TOLERANCE
FROM "Z" = 3.000 TO "Z" = 1.87 — TOLERANCE
FROM "Z" = 3.000 TO "Z" = 4.000 — TOLERANCE
FOR "Z" GREATER THAN 4.000 — TOLERANCE = ±.030.
MACHINED PORTION OF CONTOUR MUST BLEND SMOOTHLY WITH AS CAST SURFACE.
2.00 DIA
3.00
3 BOSSES EQUALLY SPACED
4.870 DIA
(REF)
.53 (TYP 3 PLACES)
.78 DIA
(TYP 6 PLACES)
SECTION K-K
3 BOSSES
EQUALLY SPACED
6
5

97 ③

SYM	ZONE	DESCRIPTION	DATE	APPROVED
A		SEE ENGINEERING ORDER	[illegible]	[illegible]
B		SEE ENGINEERING ORDER	[illegible]	[illegible]



SECTION **H-H**
TWICE SIZE



VIEW **P**
TWICE SIZE

S SHOWN

975

16.
15. PENETRANT INSPECT PER MIL-I-6866.
14. ALL CAST FILLET RADII .23-.17.
13. ALL CAST CORNER RADII .03-.02.
12. ALL CAST WALLS .19-.13.
11. INTERIOR CAST SURFACES 250/. EXTERIOR CAST SURFACES 500/.
10. MAX DRAFT ANGLE 1°.
9. FINISH ALL SURFACES MARKED √ TO √.
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .005 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030-.015.
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED

...NAL TOLERANCE SYMBOLS

...NDOR IDENT. SYMBOL, 4' ...EXTERNAL NON MACHINED ...ECH SPEC MC-14, CLASS I.

...MUST BLEND SMOOTHLY.

QTY REQD	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT	ZONE
		-5		MACHINED CASTING - MADE FROM -3					
		-3		SAND CASTING		AL ALLOY 356-T6	AMS 4217		

LIST OF MATERIAL

REQD	NEXT ASSY	USED ON
1	369791	369780

	SIGNATURES	DATES
	[illegible]	10-19-63
	[illegible]	11-4-63
	[illegible]	11-4-63
	[illegible]	11-4-63
	[illegible]	11-4-63
	[illegible]	11-15-63
	[illegible]	11-14-63

HEAT TREATMENT: AGED — PROCESS: ANODIZE MIL-A-8625 TYPE I

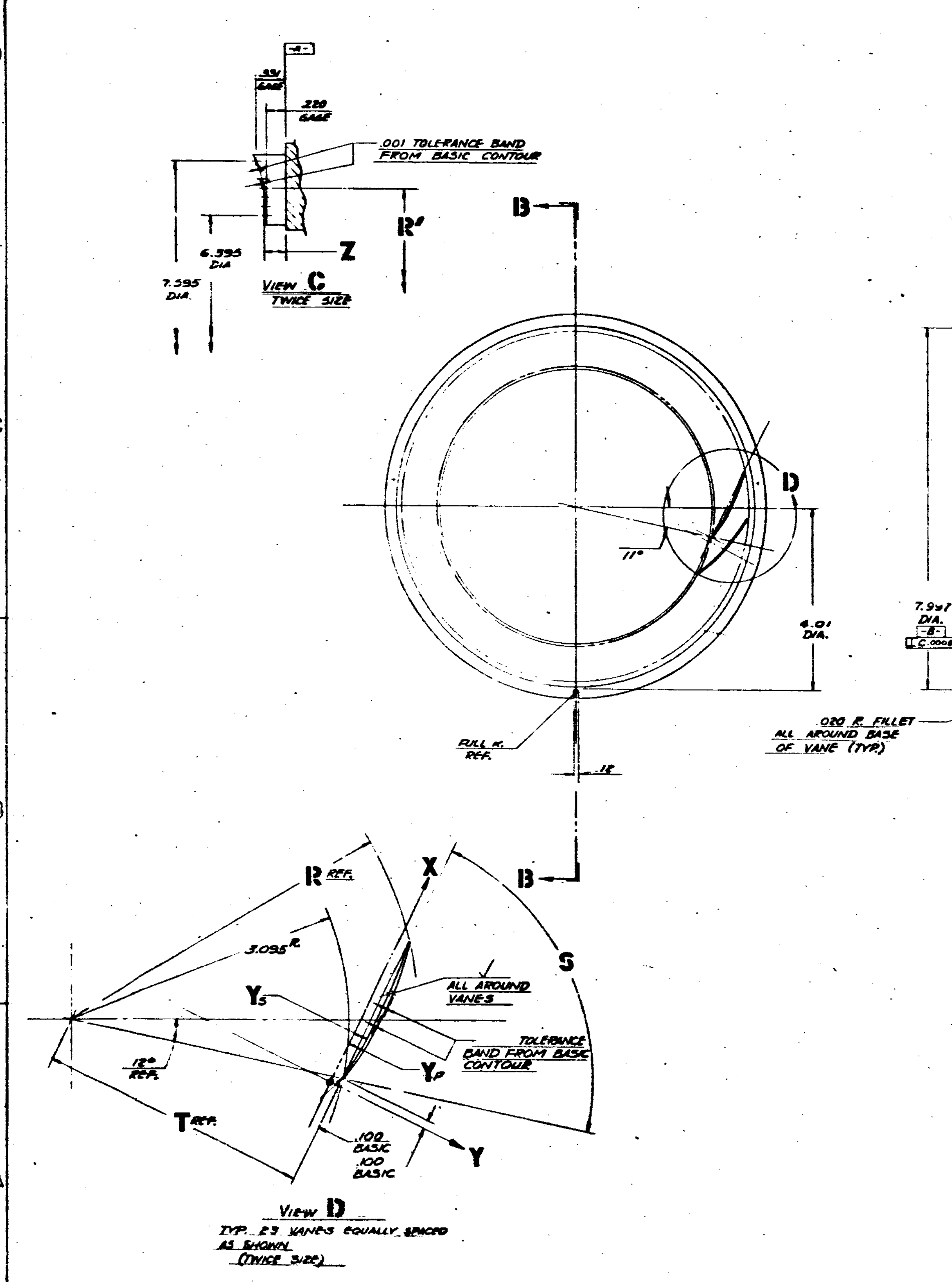
SCROLL, ASSEMBLY, COMPRESSOR

CODE IDENT NO.	SIZE	DWG NO.
99193	J	369757

SHEET 1 OF 1

PART NUMBER	R RAD. REF.	S ANGLE	T REF.
369758-10	3.963	72°45'	2.964
369758-20	3.875	75°45'	3.006
369758-30	3.807	78°45'	3.041

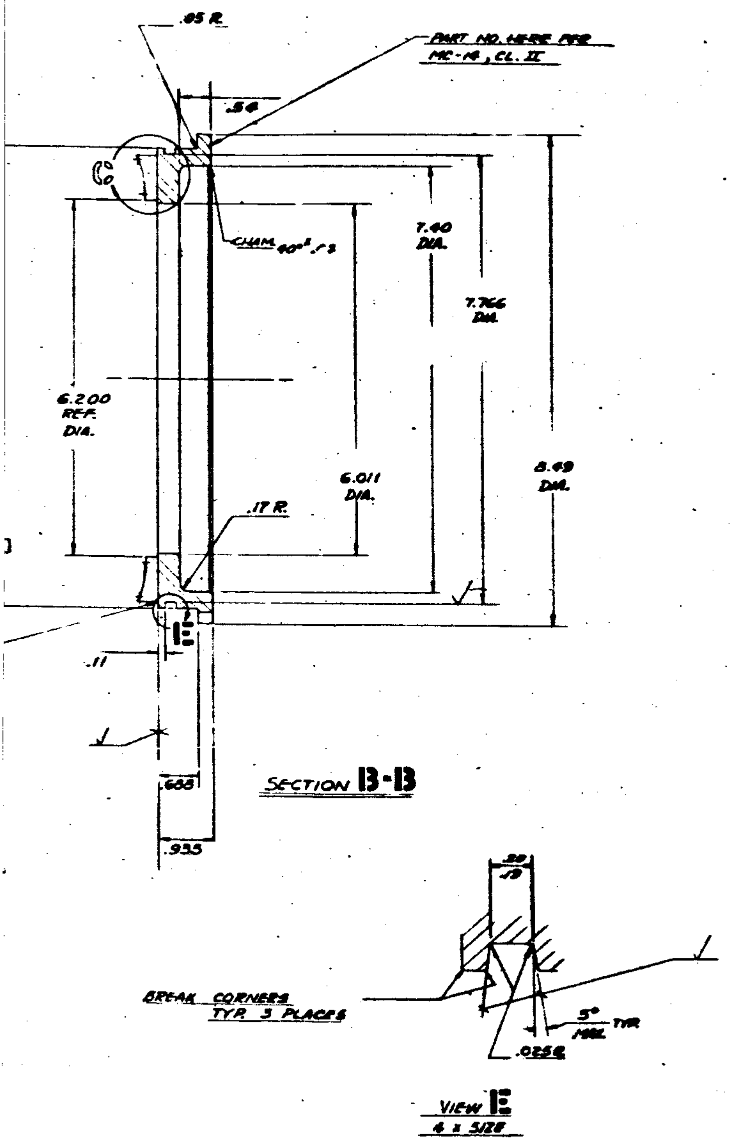
APS-5109-R



X 369758

98

1



98 (2)

11. PENETRANT INSPECTION PER MIL-I-6866

10. POSITIONAL & GEOM. TOL. SYM. PER MIL-STD-8

9. MACHINED SURFACES FLAT WITHIN .001 PER

			347 CRES	MIL-S-6721
PART NO.	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION

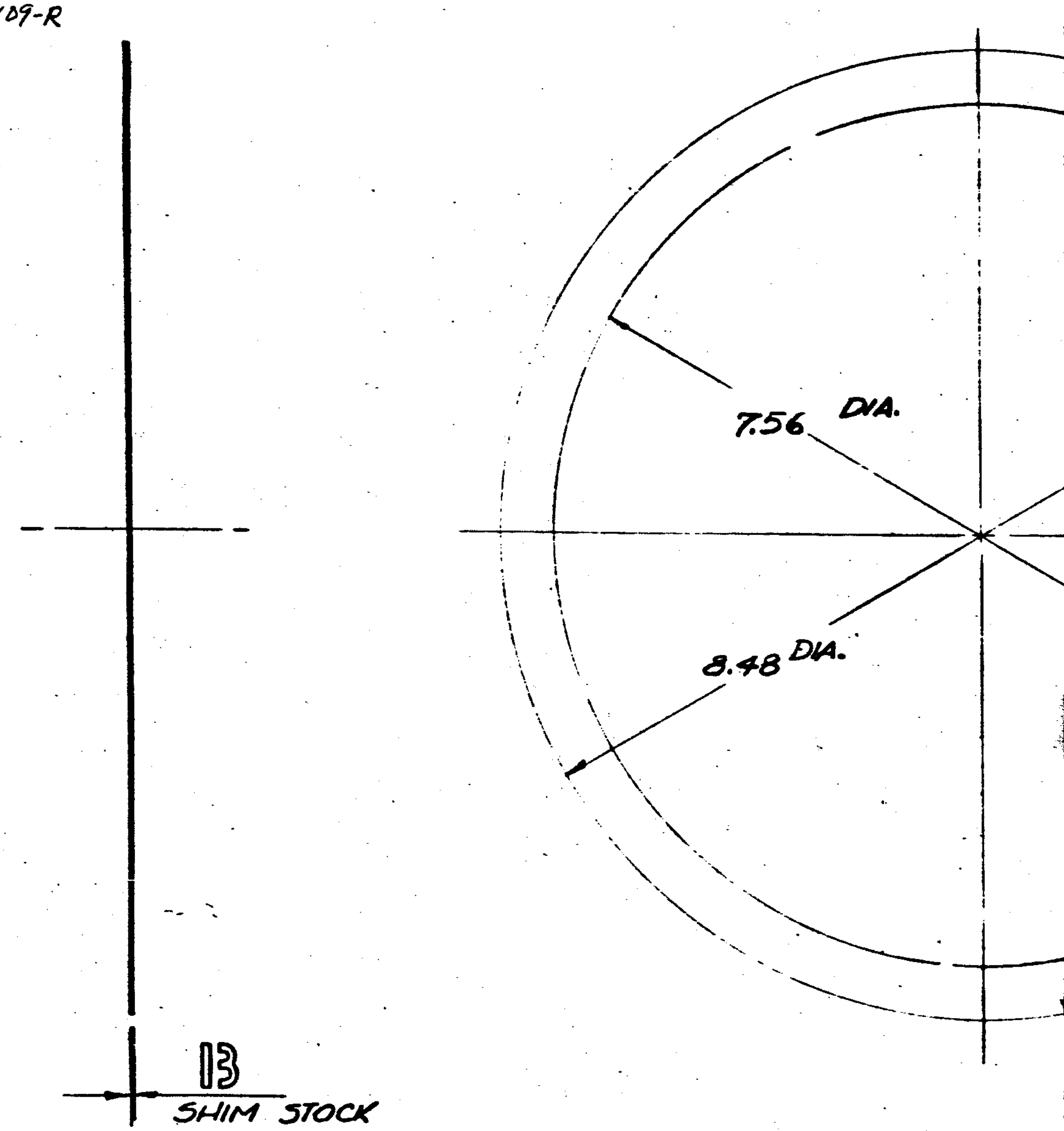
LIST OF MATERIAL

DIFFUSER, COMPRESSOR

99193 | X 369758

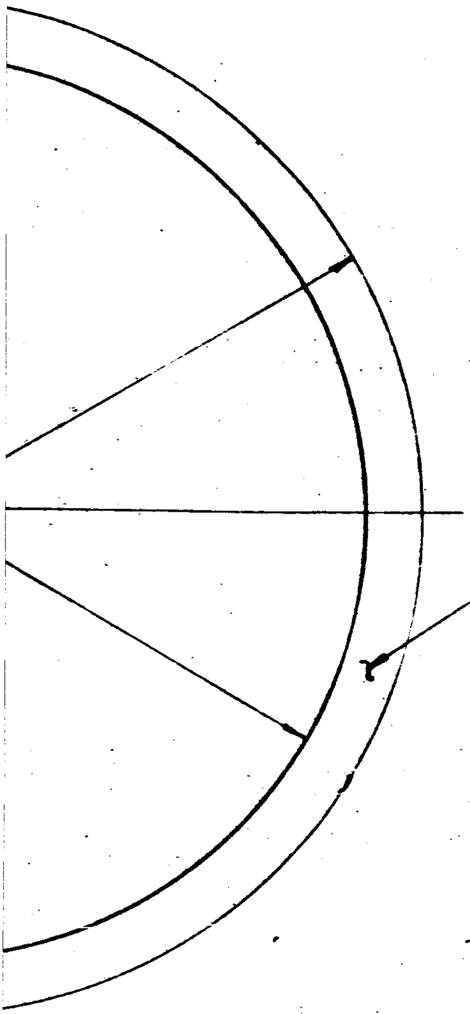
PART NO.	13 DIM.
369759-3	.002
369759-6	.004
369759-7	.016

APS-5109-R



10. PART TO BE FREE OF WRINKLES
9. SHEARED EDGES PERMISSIBLE
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
~~5. [illegible]~~
4. MACHINED FILLET RADII .030 - .015
~~3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX.~~
NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

990



REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

25 (2)

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						CRES	MIL-S-6721	

←ASSYS

LIST OF MATERIAL

(-3)		
(-5)		
(-7)	369731	369750
REQD.	NEXT ASSY.	USED ON

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

SIGNATURES		DATES
DFT.		10-21-63
CHK.		10-25-63
MFG. ENG.		
MAT. & PROCESS		
STRESS		
AERO.		
APP.		10-25-63
APP.		
DESIGN ACTIVITY APP.		10-25-63
OTHER ACTIVITY APP.		

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE
SHIM , HOUSING, DIFFUSER

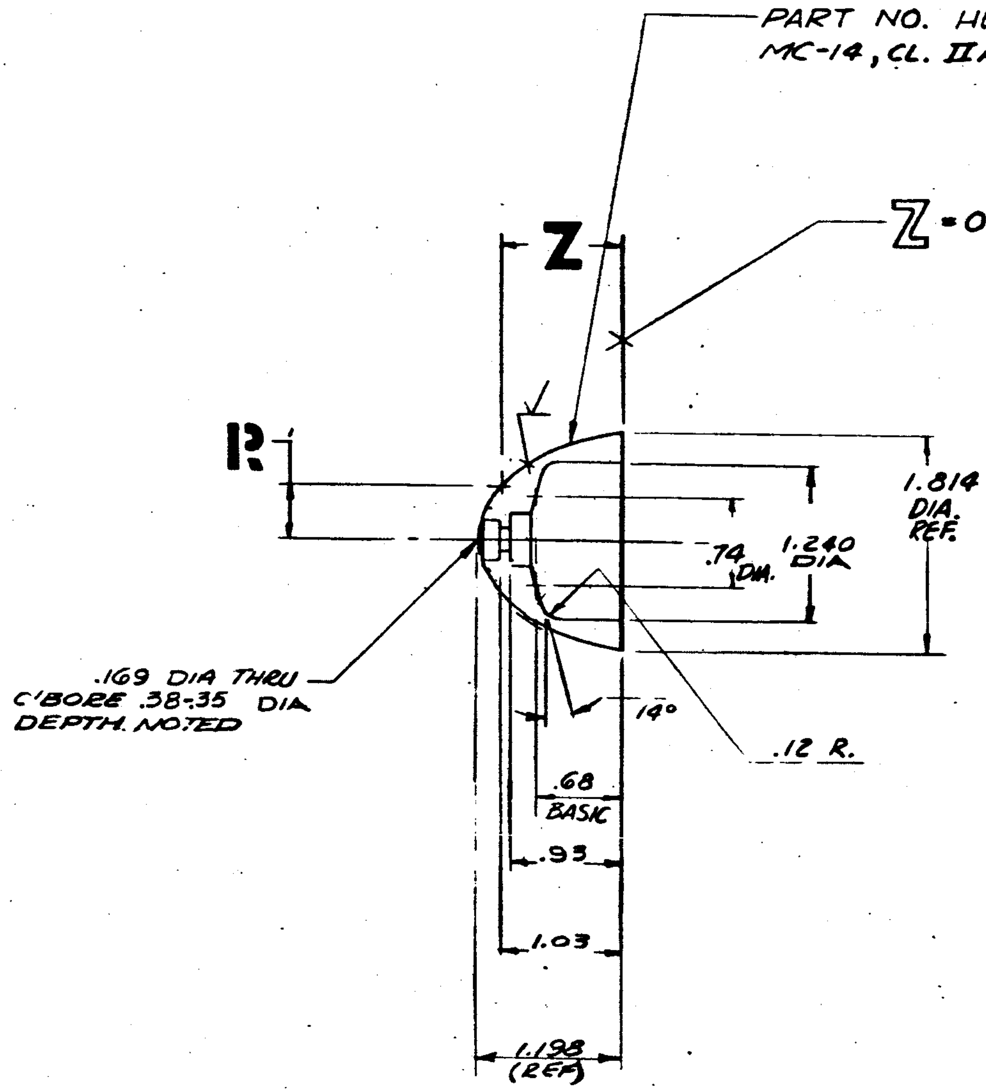
CODE IDENT NO.	SIZE	DWG. NO.
99193	C	X 369759

SCALE FULL | WT. — | SHEET 1 OF 1

DWG. NO. X 369759 | LAST —

Z	R

APS-5109-R



10. PENETRANT INSPECT PER MIL-I-6866

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1-312.

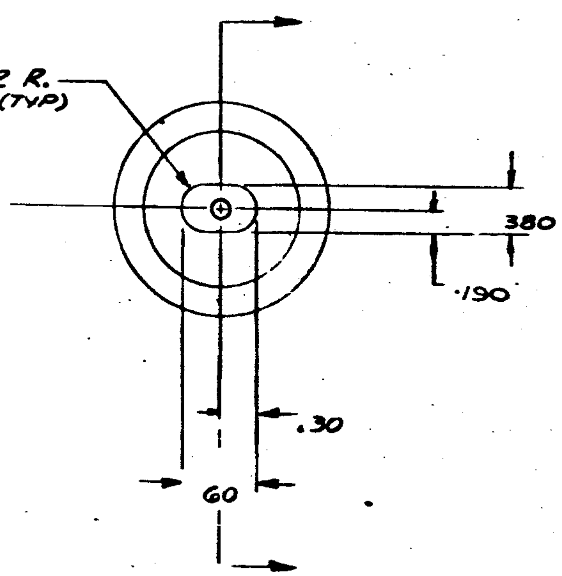
QT
REQ
HEA
HA

100 (1)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

PER
IIB



100 2

...Y. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						ALUM ALLOY 6061-T6	QQ-A-325	

← ASSYS — LIST OF MATERIAL

...D.	NEXT ASSY.	USED ON
	369731	369730

...T TREATMENT	PROCESS
	NAME ANODIZE
	SPEC MIL-A-8625 TYPE I

SIGNATURES		DATES
DR.		10-24-63
CHK.		11-7-63
MFG. ENG		
MAT. & PROCESS		11-7-63
STRESS		11-7-63
AERO		
APP		11-11-63
APP		
DESIGN ACTIVITY APP.		11-11-63
OTHER ACTIVITY APP.		

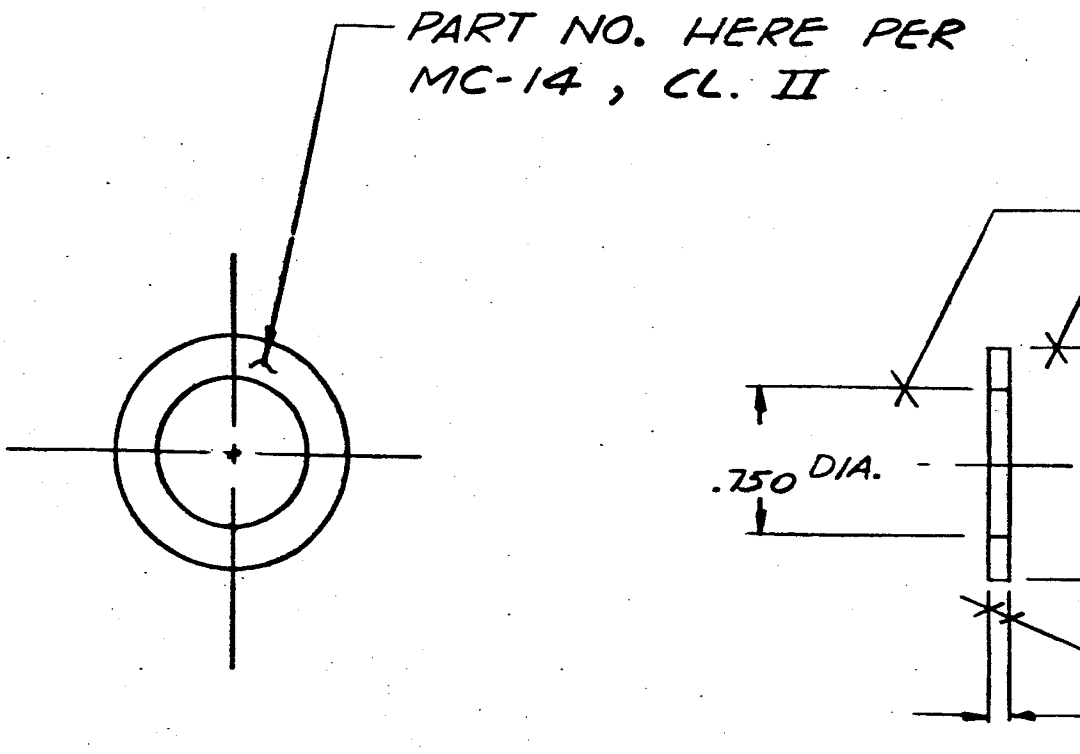
AiResearch Manufacturing Company of Arizona, Phoenix, Arizona — The Garrett Corporation

DWG. TITLE: SPINNER, IMPELLER

CODE IDENT NO. 99193 | SIZE C | DWG. NO. 369770

SCALE FULL | WT. | SHEET 1 OF 1

DWG. NO. 369770



10. OPTIONAL MAT'L:
CRES 302 - MIL-S-7720

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015.
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

QTY. REQD.	ITEM NO.	PART NO.
←ASSYS		

REQD.	NEXT ASSY.	USED ON
1	369731	369730

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

101 (1)

SYM	REV DESCRIPTION

CONCENTRIC

1.236 DIA

PARALLEL

.115

SYM	DESCRIPTION	CODE IDENT

LIST OF MATERIAL

SIGNATURES		DATES
DFT.		10-25-63
CHK.		11-7-63
MFG. ENG.		
MAT. & PROCESS		11-7-63
STRESS		11-7-63
AERO		
APP.		11-11-63
APP.		
DESIGN ACTIVITY APP.		11-11-63
OTHER ACTIVITY APP.		

AiResearch Manufacturing Co

PHOENIX, ARIZO

DWG. TITLE

WASA

HW 11-14-63

CODE IDENT NO.	SIZE
99193	B

SCALE FULL | WT.

2

ISIONS

	DATE	APPROVED

LAST LTR. —

DWG. NO. 369771

CRITICAL ITEM

SATISFACTORY PERFORMANC OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

	CRES 303	MIL-S-7720	
	MATERIAL	SPECIFICATION	UNIT WT.

npany of Arizona

NA

A Division of THE GARRETT CORPORATION

HER, FLAT

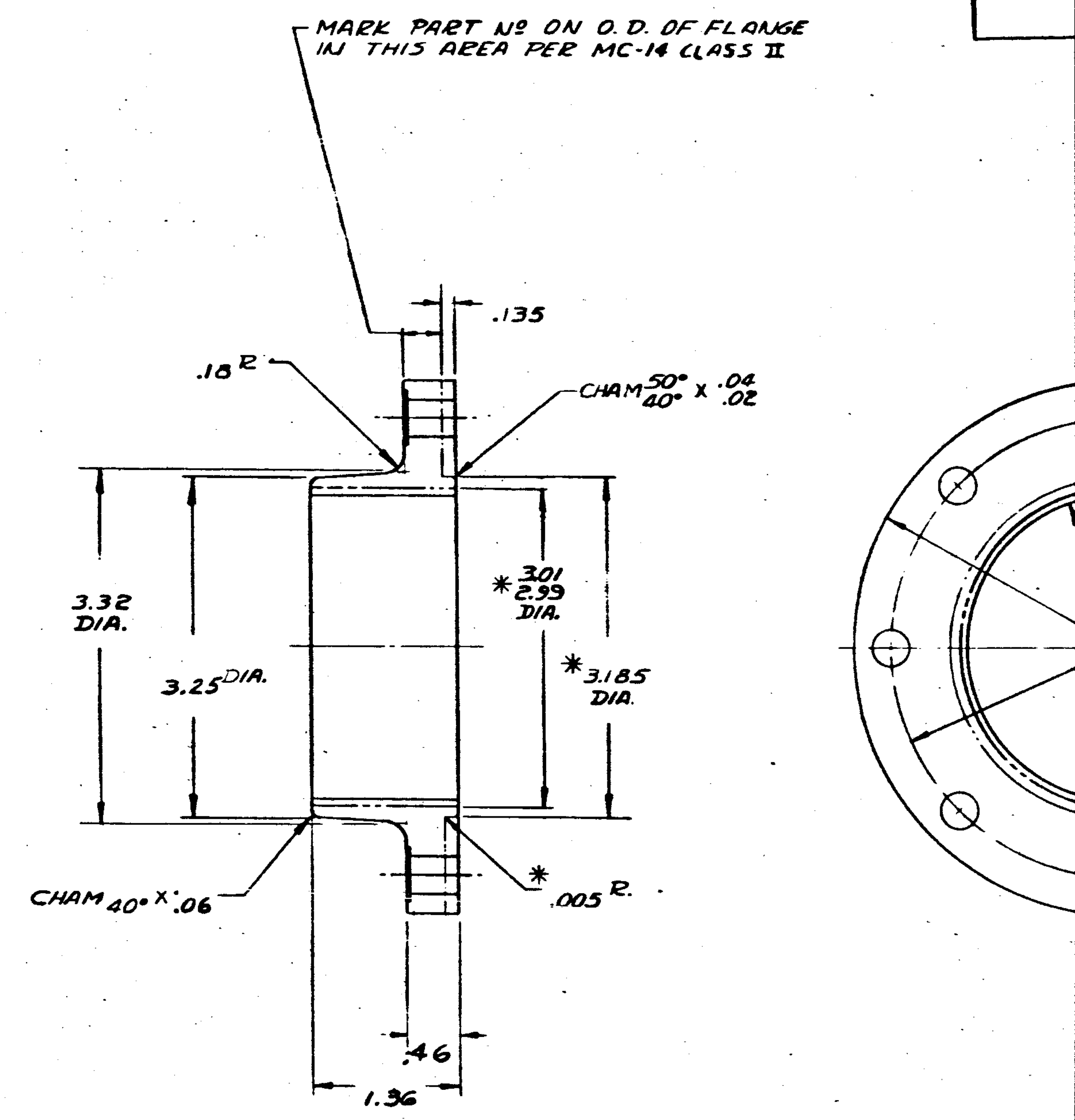
1013

DWG. NO.

369771

SHEET 1 OF 1

APS-5109-R



13. AFTER WELDING IN PLACE, CUSTOMER TO STRESS RELIEVE PRIOR TO FINAL MACHINING BY HEATING TO 750-700°F. FOLLOWED BY AIR COOL.

12. OPTIONAL MATERIAL PER MIL-S-6721

11. DIMENSIONS MARKED WITH ASTERISK (*) TO BE MACHINED BY CUSTOMER

10. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8

9. FINISH ALL OVER ✓

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING.

4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

2. SURFACE ROUGHNESS PER MIL-STD-10.

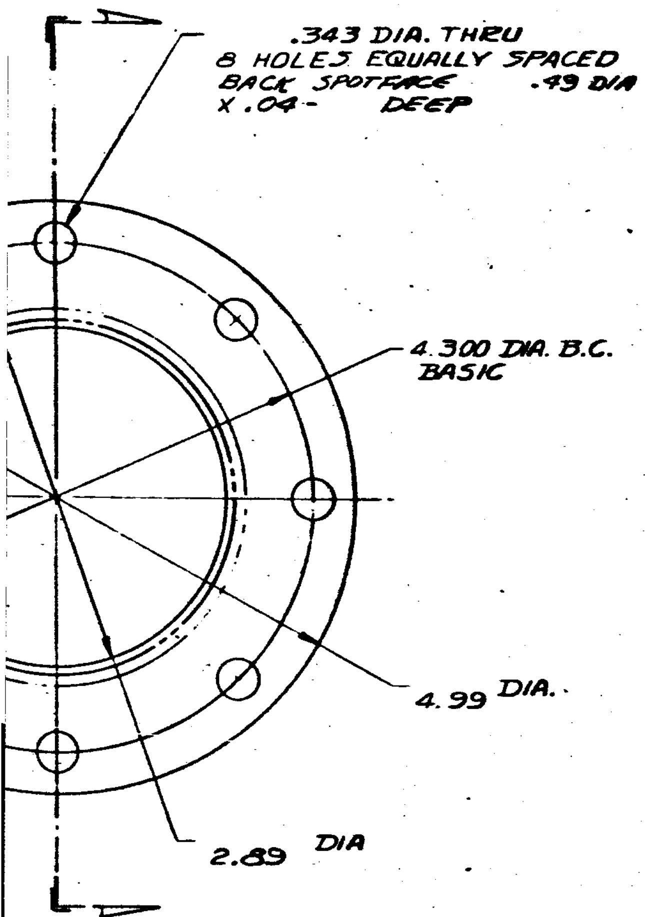
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

PS549 - SIMS E 199 HERCULENE

1020

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



LAST LTR —

DWG. NO. 369778

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPL 1.313.

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						CRES	QQ-S-763 (321 OR 347)	

← ASSYS — LIST OF MATERIAL

		SIGNATURES	DATES
		DFT. N. Walker	11-8-63
		CHK. [illegible]	11-8-63
		MFG. ENG.	
		MAT. & PROCESS [illegible]	12-3-63
369730		STRESS	
NEXT ASSY.	USED ON	AERO	
HEAT TREATMENT	PROCESS	APP. [illegible]	11-12-63
HARDNESS: NOTED	NAME	APP.	
SPEC.: NOTED	SPEC.	DESIGN ACTIVITY Wallerow	12-3-63
		OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
A DIVISION OF THE GARRETT CORPORATION

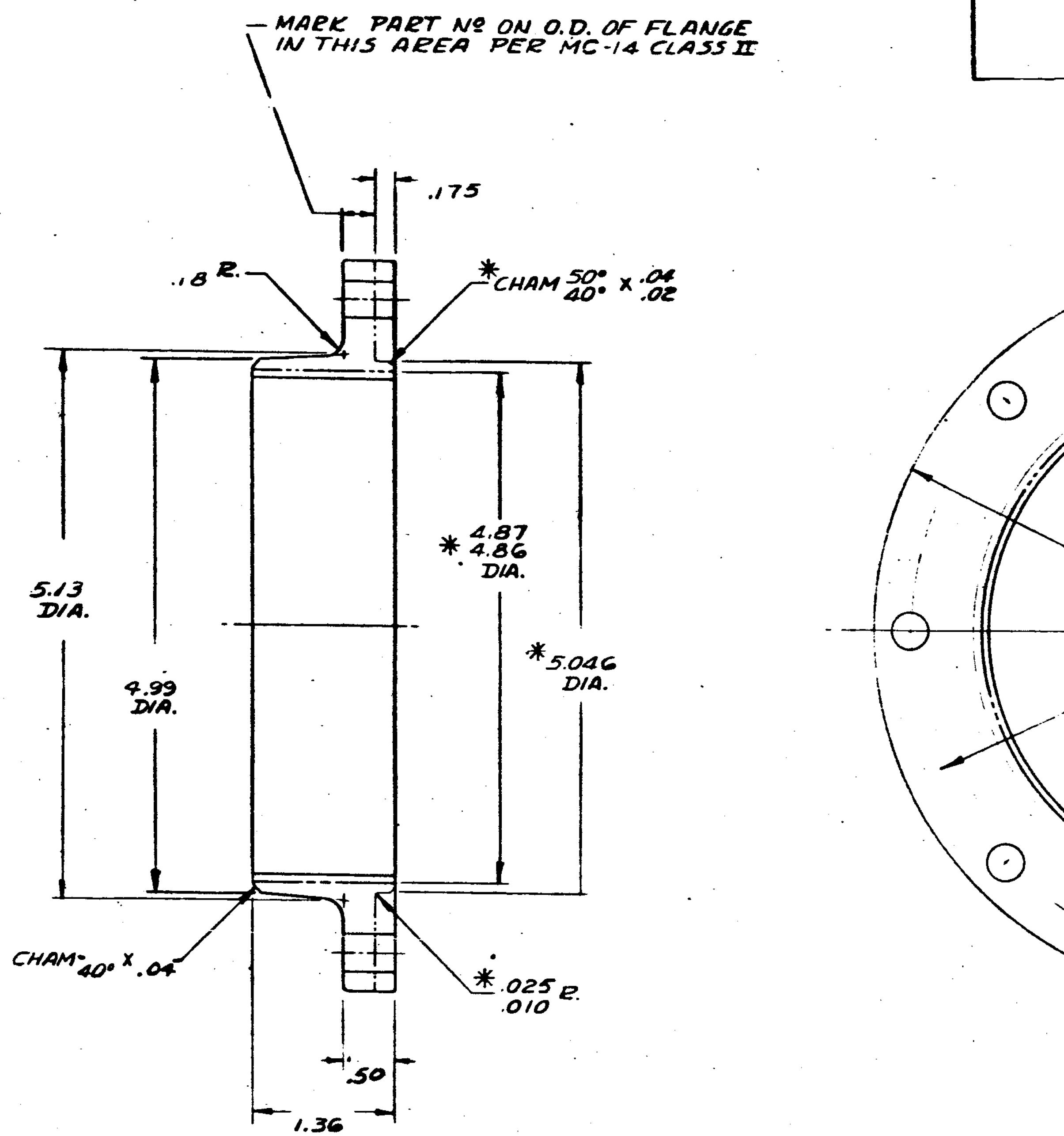
DWG. TITLE
FLANGE, COMPRESSOR OUTLET

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369778

SCALE FULL | WT. | SHEET 1 OF 1

10 2 (2)

PS-5109-R



13. AFTER WELDING IN PLACE, CUSTOMER TO STRESS RELIEVE PRIOR TO FINAL MACHINING BY HEATING TO 750-700° F. FOLLOWED BY AIR COOL.

12. OPTIONAL MATERIAL PER QQ-S-763

11. DIMENSIONS MARKED WITH ASTERISK (*) TO BE MACHINED BY CUSTOMER

10. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8

9. FINISH ALL OVER ✓

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING.

4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

2. SURFACE ROUGHNESS PER MIL-STD-10.

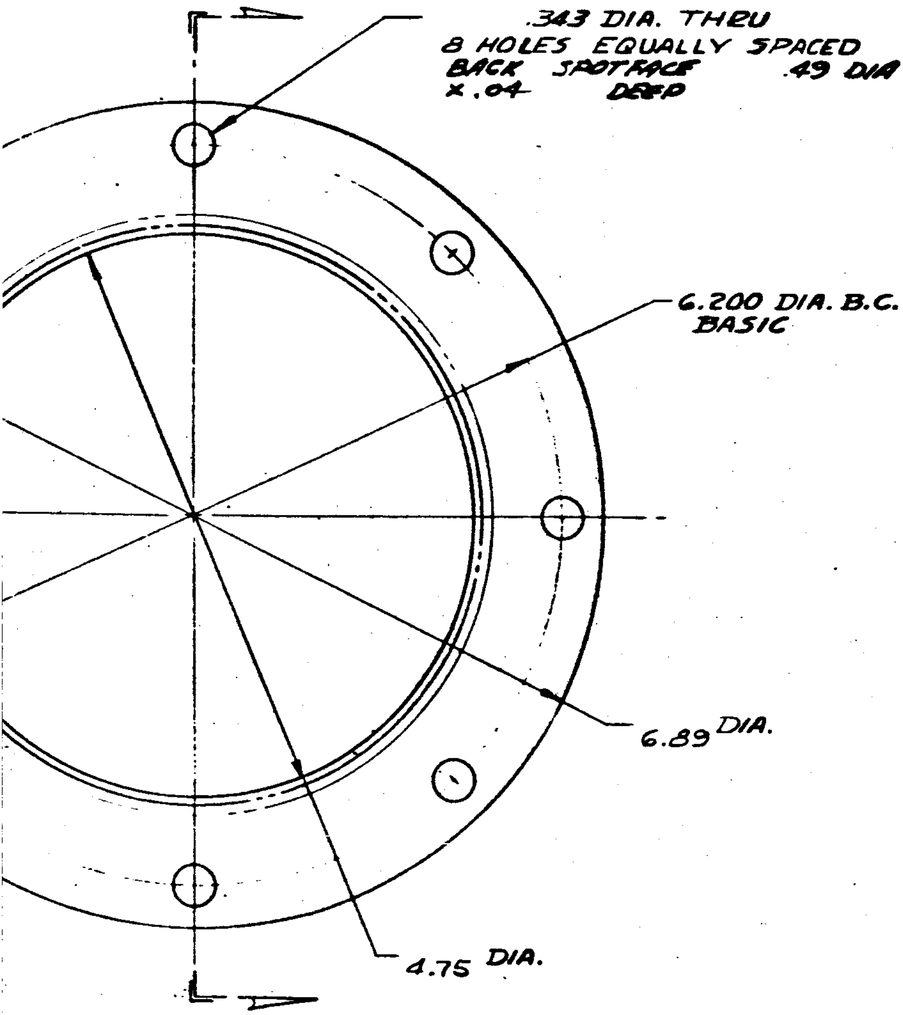
1. DIMENSIONS ARE IN INCHES.

UNLESS OTHERWISE SPECIFIED.

P0048 - 8M68 - K & E 163 HERCULENE

1030

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



DWG. NO. 369779 LAST LTR.

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR. 1.313.

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						CRES	MIL S-6721 (321 OR 347)	

←ASSYS

LIST OF MATERIAL

	369730	
QTY. REQD.	NEXT ASSY.	USED ON

HEAT TREATMENT	PROCESS
HARDNESS: NOTED	NAME
SPEC: NOTED	SPEC.

SIGNATURES	DATES
DFT. H. Walker	11-8-63
CHK. Hanford	11-9-63
MFG. ENG.	
MAT. & PROCESS E. J. Poli	12-2-63
STRESS	
AERO	
APP. [signature]	11-17-63
APP.	
DESIGN ACTIVITY APP. Williams	12-3-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
A division of THE GARRETT CORPORATION

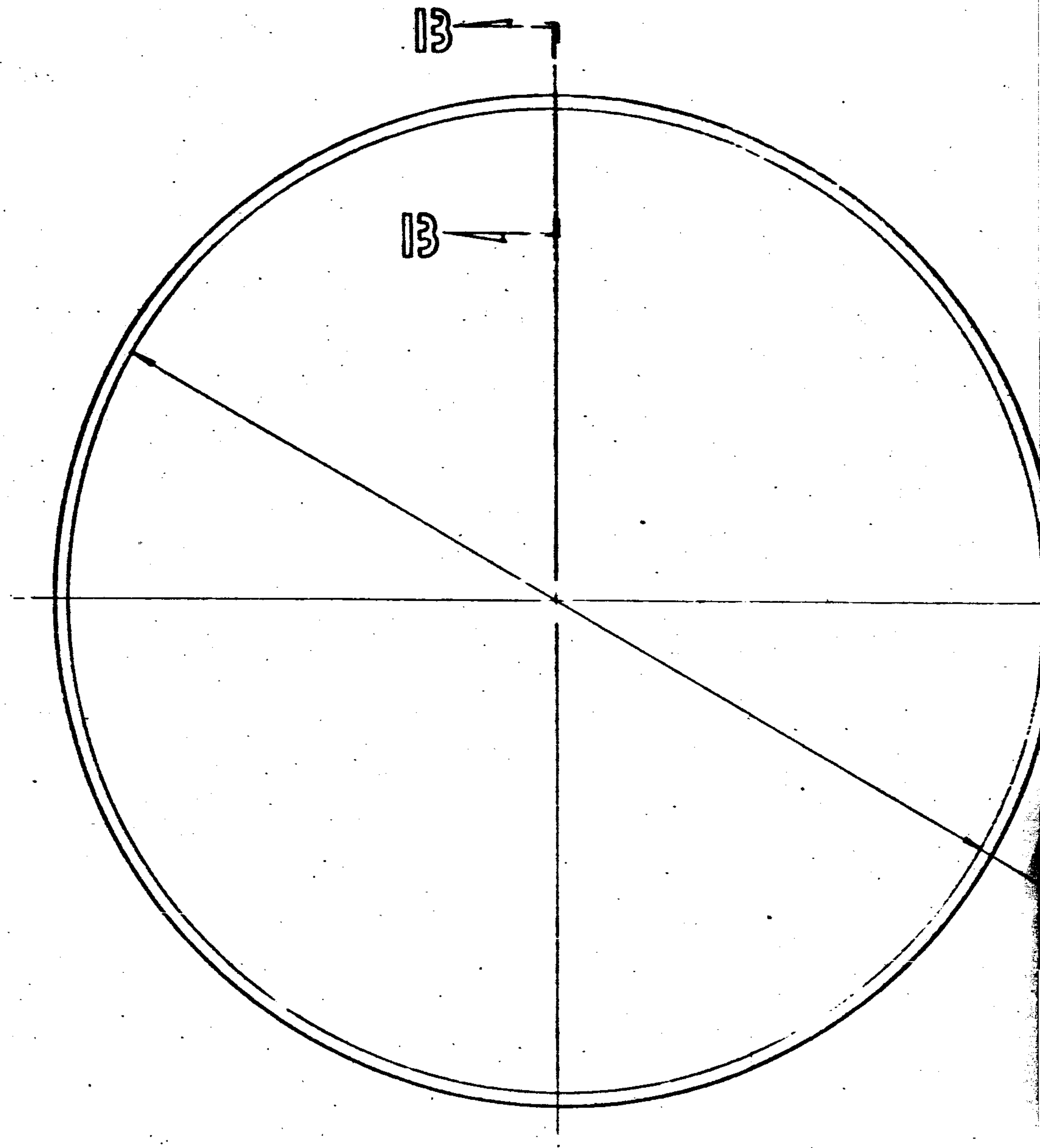
DWG. TITLE
FLANGE, COMPRESSOR INLET

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369779

SCALE FULL | WT. | SHEET 1 OF 1

103 (2)

APS-5108-R
APS-5109-R



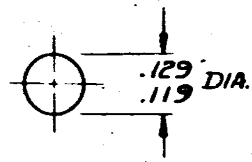
13. PARTS PROCURED BY VENDOR PART NO SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.
12. PROCUREMENT SOURCE(S) PER ASL 369813
11. ALL DESIGN & PART NO CHANGES MUST RECEIVE PRIOR AIRESEARCH APPROVAL.
10. IDENTIFY ALL PACKAGING WITH AIRESEARCH PART NO.
9. DATE OF MANUFACTURE MUST BE MARKED ON ALL SPARE PARTS PACKAGES.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

P5545 - 21MS - K & E 163 HERCULENE

10

REVISIONS		
DESCRIPTION	DATE	APPROVED



SECTION 13 - 13
SCALE: 4/1

ALL DIAMETERS OF CROSS SECTION MUST EQUAL .129 - .119 DIA.

369813

TY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
						VITON "A"	MIL-R-25897 TYPE I, CLASS I	

←ASSYS

LIST OF MATERIAL

NEXT ASSY.	USED ON
369741	369740
369731-20	369730

SIGNATURES	DATES
DFT. M Walker	11-13-63
CHK. Walkers	11-13-63
MFG. ENG	
MAT. & PROCESS R L Fischer	11-14-63
STRESS	
AERO	
APP.	11-14-63
APP.	
DESIGN ACTIVITY APP. Walkers	11-14-63
OTHER ACTIVITY APP.	

HEAT TREATMENT | PROCESS

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

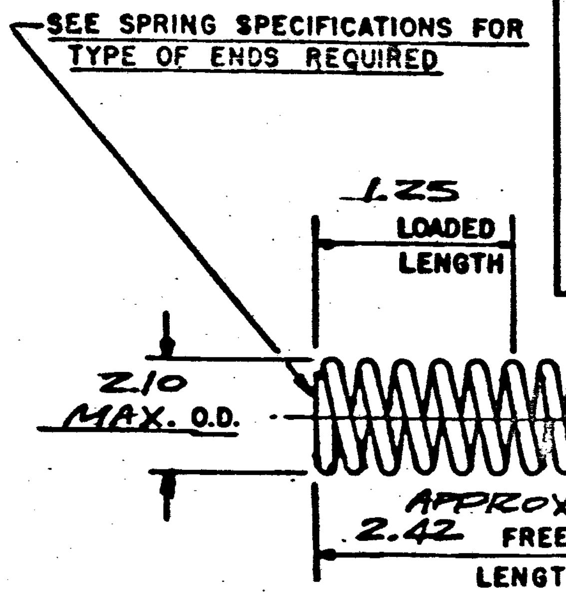
DWG. TITLE
SEAL, "O" RING

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	369813

SCALE FULL & NOTED | WT. | SHEET 1 OF 1

104 (2)

APS-5108-R
APS-5109-R



			NOTED
R.H.	L.H.	NO. REQ.	SIZE
DASH NO.			
CAL. WT.			[illegible] 7-24-
WT.			DRAFTSM
FINISH			
HEAT TREAT	NOTED		
ISSUE	DATE		

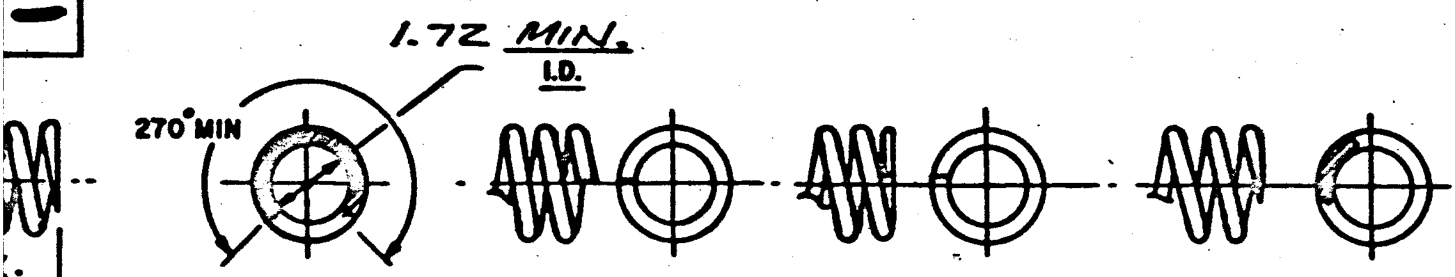
1. SPRING SHALL NOT TAKE A PERMANENT SET WHEN COMPRESSED TO SOLID HEIGHT.

NOTES: UNLESS OTHERWISE SPECIFIED.

105 Ø

111917

ZONE	SYM.	REVISION	DATE	DRFTM.	APP.



CLOSED ENDS & GROUND SQUARE TYPE 1

PLAIN ENDS TYPE 2

CLOSED ENDS SQUARED NOT GROUND TYPE 3

PLAIN ENDS GROUND SQUARE TYPE 4

SPRING SPECIFICATIONS

1. .162 DIAMETER OF WIRE
2. 35.0 LB. LB. AT LOADED LENGTH
3. (REF.) 30.0 LB. LB. PER INCH (SPRING RATE) BETWEEN LENGTHS OF INCHES AND INCHES
4. 6 TOTAL NUMBER OF COILS
5. 4 ACTIVE COILS
6. — MAXIMUM SOLID HEIGHT
7. LEFT HAND COILED RIGHT HAND COILED
8. I TYPE OF ENDS
9. SHAFT DIAMETER OVER WHICH SPRING WILL FUNCTION
10. HOLE DIAMETER IN WHICH SPRING WILL FUNCTION

THE ABOVE REQUIREMENTS AS CHECKED OR NOTED WILL PROVIDE DATA TO PRODUCE THIS SPRING. BLANK SPACES WILL INDICATE NO REQUIREMENTS.

DESCRIPTION	COND.	SPECIFICATION	COND.	ZONE
CRES. ST. WIRE "SPRING TEMPER"	TYPE "B"	QQ-W-423 COMP. FS, (302)		

MATERIAL (COMM.) | MATERIAL SPECIFICATION

DRAWN	CHECKER	APP.	APP.	APP.	APP.
1-25-56	1-25-56	1-25-56	1-25-56	1-25-56	— —

NO. REQ.	NEXT ASSY.	OUTLINE	MODEL
	108031-5	108030-5	

UNLESS OTHERWISE SPECIFIED:
1. DIMENSION TOLERANCES ARE: DECIMAL = ± .010 ANGLES = ±0°30'.
2. REMOVE BURRS AND BREAK SHARP EDGES.
3. DIMENSION LIMITS HELD AFTER PLATING.
4. R.M.S. √ SURFACE ROUGHNESS PER NAS NO. 30

AIRESEARCH MANUFACTURING COMPANY PHOENIX, ARIZONA SCALE NONE

SPRING — COMPRESSION

AREA SQ. FT. 1.30 | DWG. SIZE B | DWG. NO. 111917

105 (2)

BEARING DESCRIPTION BALL, ANGULAR CONTACT		GRADE AIRESEARCH 5
INNER RING	OUTER RING	ASSEMBLED BEARING CHARACTERISTICS
MATERIAL: SAE 52100 STEEL	MATERIAL: SAE 52100 STEEL	TOTAL DIAMETRAL (DIAMETRAL, AXIAL) CLEARANCE OF
BORE: .9841 TAPER/FT:	OD: 1.8504 TAPER/FT:	.0019 UNDER 2 LBS GAGE LOAD
WIDTH: .4624	FLANGE OD:	CONTACT ANGLE REF: 20°
RACE DEPTH REF. 20 MIN %BALL DIA.	WIDTH: .4624	MAXIMUM TORQUE: ____ (IN OZ. IN. LBS) AT ____ RPM
RACE CURVATURE REF. 52-53 %BALL DIA.	FLANGE WIDTH:	UNDER: ____ (GRAMS, LBS) ____ (THRUST, RADIAL) LOAD
SEPARATOR PILOT LAND TO GROOVE RUNOUT: TIR	RACE DEPTH REF: 16 MIN %BALL DIA.	STABILIZED FOR OPERATION AT: SEE NOTE 1
SEPARATOR	RACE CURVATURE REF: 54-55 %BALL DIA.	____ (INNER, OUTER) RING FACE OFFSET: ____
MATERIALS: FORGED SILICON IRON BRONZE PER AMS 4616	SEPARATOR PILOT LAND TO GROOVE RUNOUT: TIR	UNDER: ____ LBS THRUST LOAD.
CONSTRUCTION: MACHINED	ROLLING ELEMENTS	SPECIAL FEATURES
ASSEMBLY: ONE PIECE	MATERIAL: SAE 52100/51100 STEEL	1. PARTS MUST NOT CHANGE IN DIMENSION IN
PILOTING SURFACE: OUTER RING	COMPLEMENT PER ROW: 13-1/4	
PILOT CLEARANCE: .008	CLOSURES	2. FACE "A" TO BE FLUSH WITH 30 LB THRUST
OPERATIONAL LUBRICANT	NUMBER: NONE	LOAD APPLIED IN DIRECTION SHOWN
NAME: OIL, SYNTHETIC AIRCRAFT GAS TURBINE, LUBRICATING	TYPE: ____ (SHIELDS, SEALS)	3. SEPARATOR POCKET SURFACE CIRCUMFERENTIALLY FORES
MILITARY SPEC NO. MIL-L-7808	MATERIAL:	AFT TO BE AT BEARING P.D. 4. SEPARATOR TO BE SILVER PLATED
BEARING PRELUBRICATION: DIP & DRAIN	CONSTRUCTION:	.0005-.0020 THICK PER AMS 2412.

PACKAGING PER AIR SPEC CP-14	PRODUCTION BULK PACK	COMMERCIAL SPARES PACK	MILITARY SPARES PACK
PRESERVATIVE:	MIL-L-6085	MIL-L-6085	MIL-P-197
AIRESEARCH PART NUMBER:	BASIC	BASIC	BASIC-4
VENDOR NAME & LOCATION	VENDOR PART AND SPECIFICATION NUMBER		
FED. SUPPLY CODE NO.	PROCUREMENT PER ASL		

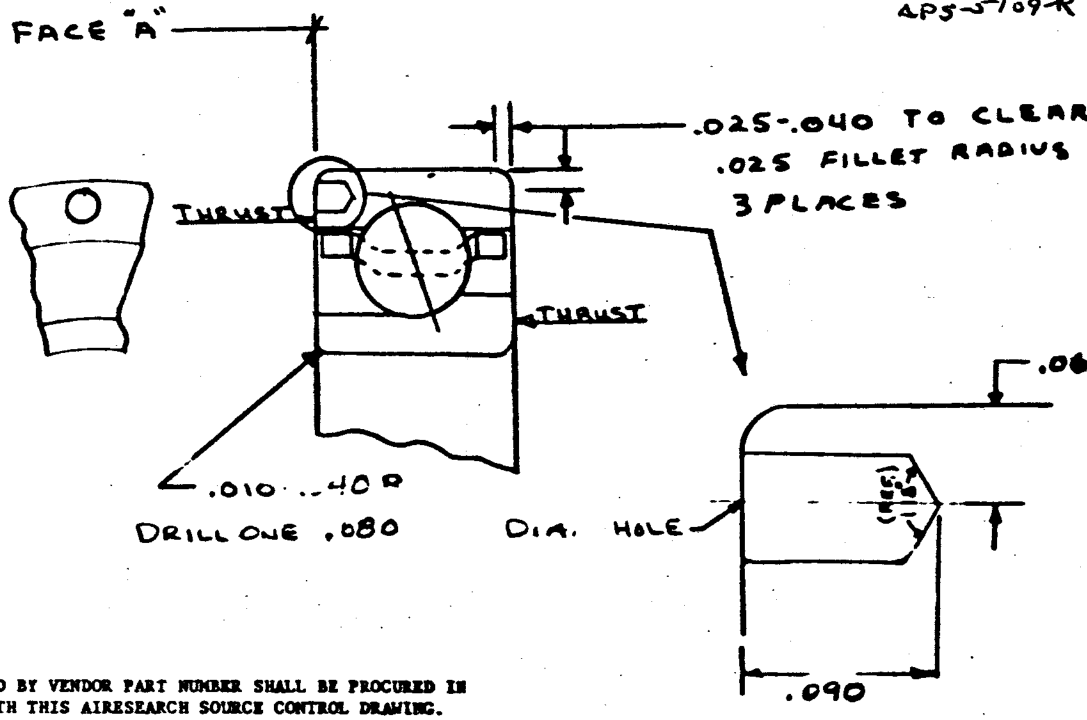
060

Form #1552B

DWG. NO. 358313

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

APS-5-108-R
APS-5-109-R



7. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.
6. IDENTIFY PACKAGING WITH AIRESEARCH PART NUMBER.
5. ALL DESIGN AND PART NUMBER CHANGES MUST RECEIVE PRIOR AIRESEARCH APPROVAL.
4. ONLY THE ITEMS LISTED ON THIS DRAWING AND IDENTIFIED BY VENDORS' NAMES, ADDRESSES AND PART NUMBERS HAVE BEEN TESTED AND APPROVED FOR USE IN THE END UNIT. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY AIRESEARCH.
3. MILITARY SPARES PACK BEARINGS ARE INTENDED TO FILL MILITARY SPARES ORDERS. BEFORE INSTALLATION WASH OUT THE PRESERVATIVE AND REPLACE WITH OPERATING LUBRICANT. AFTER THIS OPERATION THE —4 IDENTIFICATION IS DROPPED AND THE BEARINGS BECOME INTERCHANGEABLE WITH THE PRODUCTION BULK AND COMMERCIAL SPARES PACK BEARINGS. THEY SHOULD NOT BE USED IN FACTORY INSTALLATIONS BECAUSE OF THEIR RELATIVELY HIGH COST.
2. FOR ECONOMY, PRODUCTION BULK PACK BEARINGS ARE PREFERRED FOR ALL FACTORY INSTALLATIONS. COMMERCIAL SPARES PACK BEARINGS ARE INTENDED TO FILL COMMERCIAL SPARES ORDERS.
1. PRODUCTION BULK AND COMMERCIAL SPARES PACK BEARINGS ARE INTERCHANGEABLE.

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

SOURCE CONTROL DRAWING

SIGNATURES	DATES
DRF Johnson	8-15-63
CHK J. Carlson	8-15-63
APP [illegible]	8-16-63
APP [illegible]	8-17-62
APP	
APP	

NEXT ASSY	USED ON

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA
division of THE GARRETT CORPORATION

NAME
BEARING BALL, SINGLE ROW ANGULAR CONTACT

HW 8-21-63

SCALE NONE | WGT —

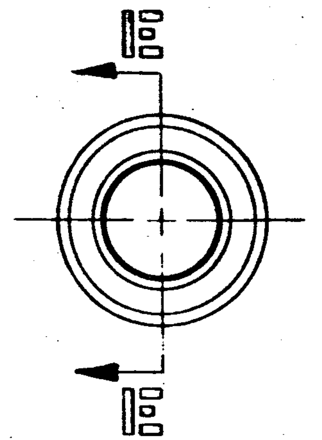
DWG. SIZE B | DWG NO. 358313

FED. SUPPLY CODE NO.

Code: 99193

166 (2)

APS-5708-R
APS-5709-R



21. OPERATING CONDITIONS -

PRESSURE, AIR SIDE, 0 PSIG.
OIL SIDE. - 2 PSIG.
TEMPERATURE, AIR SIDE, 100°F.
OIL SIDE 225°F.
LEAKAGE, AIR TO OIL, .01 LB/MIN
OIL TO AIR, 1 CC/HR.
OIL MIL-L-7808
LIFE REQUIRED 500 HOURS.

20. SEAL CASE TO BE CRES.
19. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8.

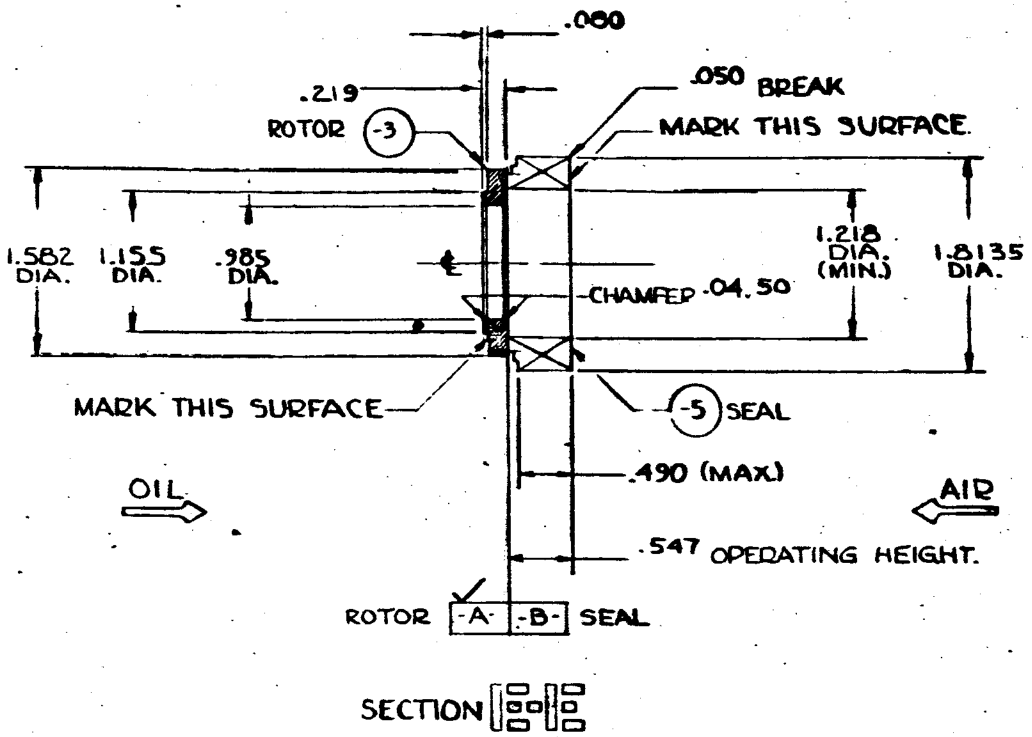
15. PROCUREMENT SOURCE(S) PER ASL
14. PART TO BE MARKED PER MC-14 CLASS II WITH AIRESEARCH NUMBER 358319.
13. ALL DESIGN AND PART NUMBER CHANGES REQUIRE PRIOR AIRESEARCH APPROVAL.
12. ONLY ITEMS LISTED ON THE APPLICABLE ASL AND IDENTIFIED BY VENDOR'S NAMES, ADDRESSES, AND PART NUMBERS HAVE BEEN TESTED AND APPROVED FOR USE IN THE END UNIT. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY AIRESEARCH.
11. IDENTIFY PACKAGING WITH AIRESEARCH NUMBER.
10. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.
9. DETAILS OF DESIGN AND CONSTRUCTION OTHER THAN SHOWN SHALL BE AT OPTION OF VENDOR.
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.
UNLESS OTHERWISE SPECIFIED.

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

1070

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



358319

	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
		-3				CRES	QQ-S-763 440 F	
QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

← ASSYS

LIST OF MATERIAL

QTY REQD.	NEXT ASSY.	USED ON
1	369741	369740
1	369731	369730
1	369721	369720

HEAT TREATMENT	PROCESS
HARDNESS	NAME
SPEC.	SPEC.

SIGNATURES	DATES
DFT. J.C. Jones	8/29/63
CHK. J.V. Matthews	9/3/63
MFG. ENG. RK	11-14-63
MAT. & PROCESS	
STRESS	
AERO.	
APP. Brand	9-3-63
APP. Hornt	11-5-63
DESIGN ACTIVITY APP. Wallner	11-13-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona

DWG. TITLE: SEAL, AIR-OIL

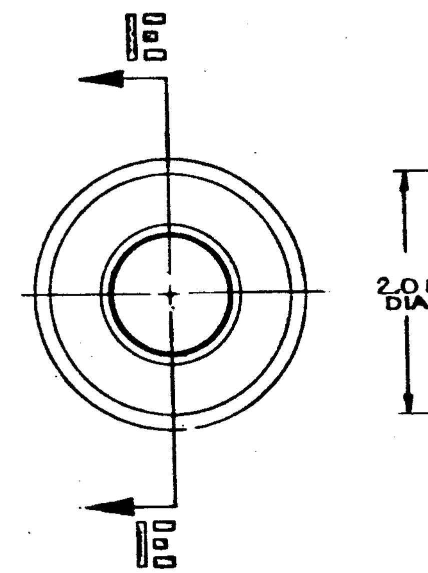
CODE IDENT NO.	SIZE	DWG. NO.
99193	C	358319

SCALE FULL | WT. | SHEET 1 OF 1

107 ②

PART Nº	SEAL	ROTOR
358320	-5	-3

APS-5108-R
APS-5109-R



OPERATING CONDITIONS	SCHEDULE V
SPEED, RPM	38,500
PRESSURE, PSIG	
GAS SIDE	-1.5
OIL SIDE	-2
TEMPERATURE, °F	
GAS SIDE	800
OIL SIDE	225
LEAKAGE (MAX)	
GAS TO OIL, LBS/MIN	.01
OIL TO GAS CC/HR.	ZERO
LIFE REQ'D, HRS.	500

21. CHROME PLATE SURFACE -A- PER QQ-C-320 CLASS 2, .002-.004 THICK.
20. SURFACE -B- LAPPED FLAT
19.
18. POSITIONAL & GEOMETRIC TOLERANCE SYMBOLS PER MIL-STD-8.
17.
16. (C) Designate Critical Characteristics
(M) Designate Major Characteristics

15. PROCUREMENT SOURCE(S) PER ASL
14. PART TO BE MARKED PER MC-14 CLASS II WITH AIRESEARCH NUMBER 358320-3, 5, OR 7
13. ALL DESIGN AND PART NUMBER CHANGES REQUIRE PRIOR AIRESEARCH APPROVAL.
12. ONLY ITEMS LISTED ON THE APPLICABLE ASL AND IDENTIFIED BY VENDOR'S NAMES, ADDRESSES, AND PART NUMBERS HAVE BEEN TESTED AND APPROVED FOR USE IN THE END UNIT. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY AIRESEARCH.
11. IDENTIFY PACKAGING WITH AIRESEARCH NUMBER.
10. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE PROCURED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.
9. DETAILS OF DESIGN AND CONSTRUCTION OTHER THAN SHOWN SHALL BE AT OPTION OF VENDOR.
8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.
7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.
6. MACHINED DIAS ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.
5. DIMENSION LIMITS HELD AFTER PLATING.
4. MACHINED FILLET RADII .030 - .015
3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.
2. SURFACE ROUGHNESS PER MIL-STD-10.
1. DIMENSIONS ARE IN INCHES.

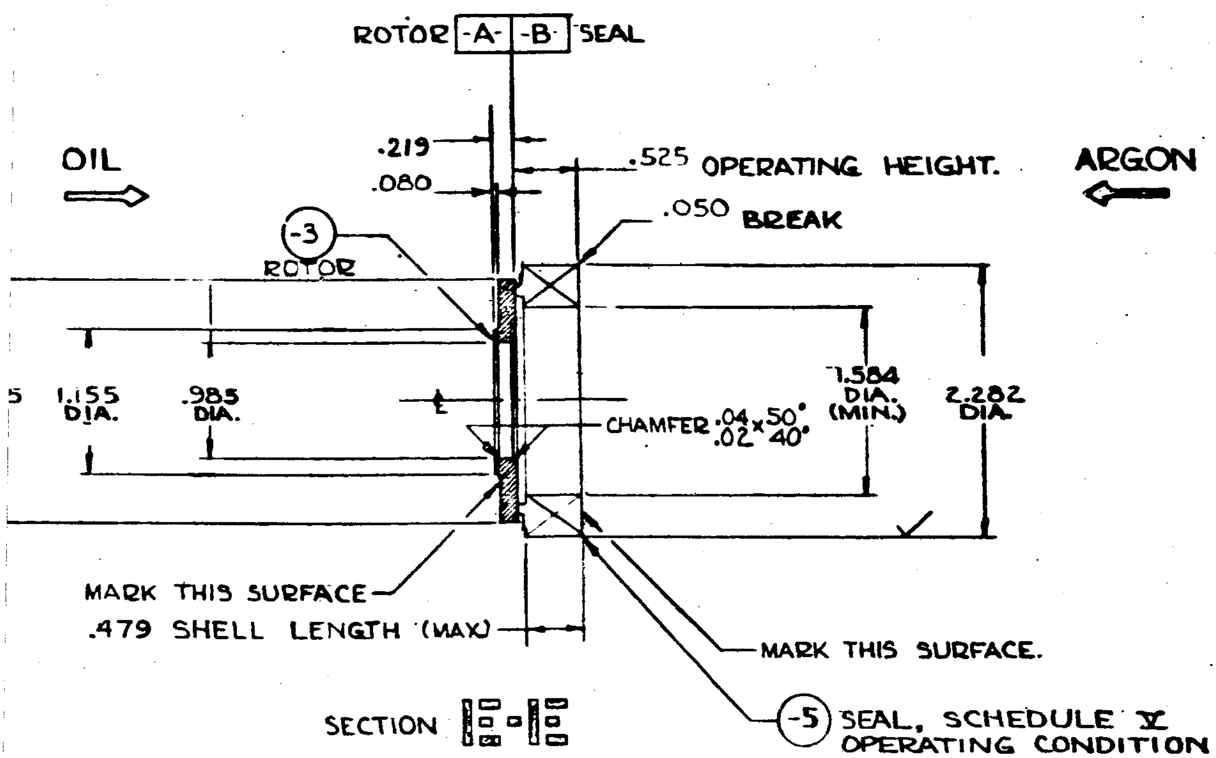
UNLESS OTHERWISE SPECIFIED.

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

1081

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



DWG. NO. 358320

QTY. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.
		-3				TOOL STEEL	AISI M-2	

←ASSYS LIST OF MATERIAL

REQD.	NEXT ASSY.	USED ON
1(-1)	369741	369740
1	369731	369730
1	369721	369720

HEAT TREATMENT	PROCESS
HARDNESS -3 Rc 64/62	NAME
SPEC	SPEC

SIGNATURES		DATES
DFT.	J C Jones	8/29/63
CHK.	J V. Matthews	9/3/63
MFG. ENG.	R.R.	11-14-63
MAT. & PROCESS		
STRESS		
AERO.		
APP.	[illegible signature]	9-3-63
APP.	P. [illegible signature]	11-5-63
DESIGN ACTIVITY APP.	[illegible signatures]	
OTHER ACTIVITY APP.		

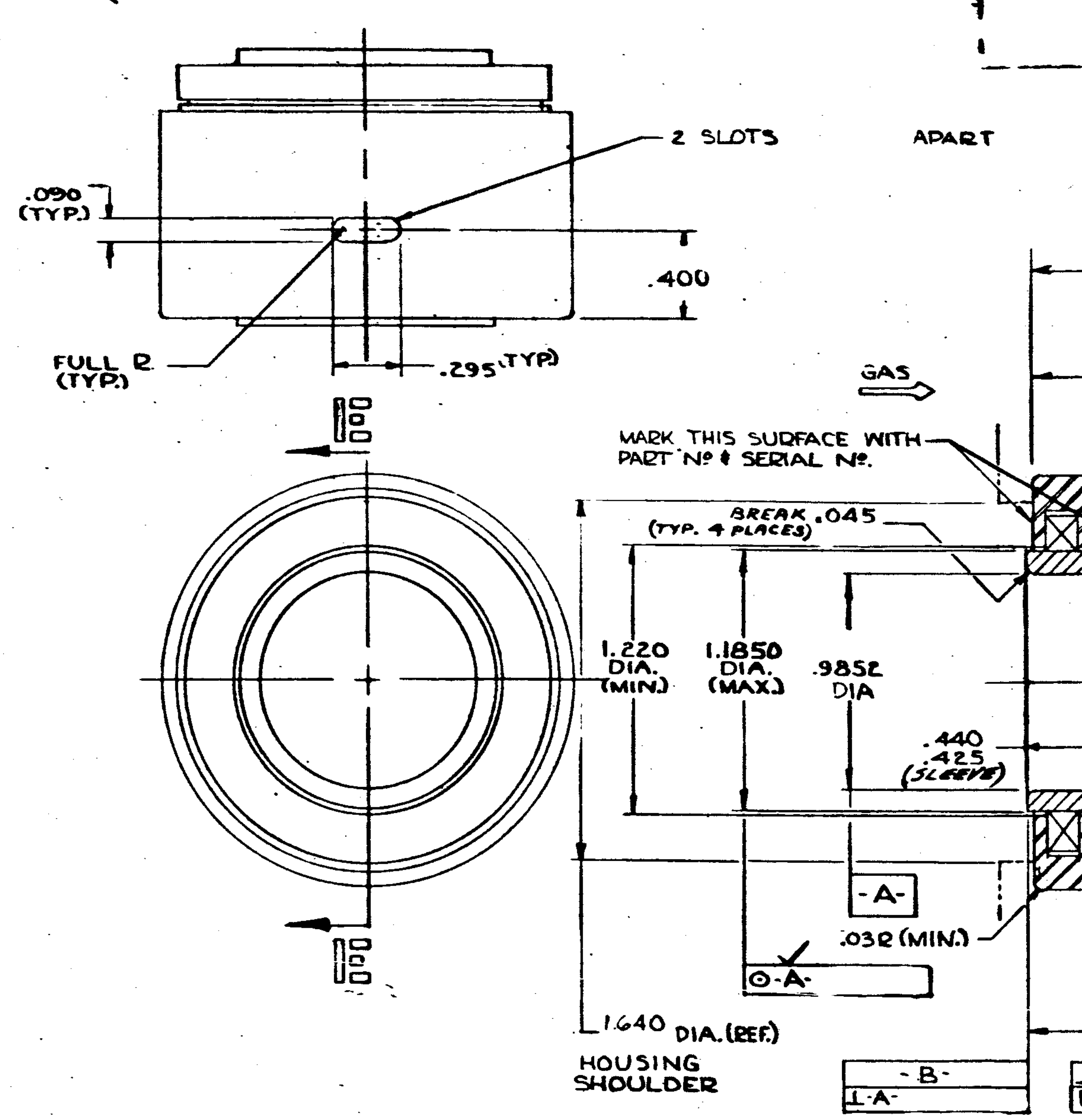
AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

DWG. TITLE: SEAL, ARGON, OIL-METAL BELLOWS

CODE IDENT NO.	SIZE	DWG. NO.
99193	C	358320
SCALE FULL	WT.	SHEET 1 OF 1

109 (2)

APS-5108-R
APS-5109-R



16. PARTS TO BE MADE, INSPECTED, STOCKED, & ISSUED AS MATCHED SETS ONLY.

15. SERIAL NUMBER CONTROL MUST BE MAINTAINED ON THIS PART THROUGHOUT MANUFACTURING AND ASSEMBLY CYCLES AND AFTER FINISH MACHINING. SERIAL NUMBERS SHALL BE APPLIED BY THE METHOD AND AT THE LOCATION SPECIFIED.

14. PROCUREMENT SOURCE(S) PER ASL

13. PART TO BE MARKED PER MC-14 CLASS II WITH AIRESEARCH NUMBER 358321 & SERIAL No.

12. ALL DESIGN AND PART NUMBER CHANGES REQUIRE PRIOR AIRESEARCH APPROVAL.

11. ONLY ITEMS LISTED ON THE APPLICABLE ASL AND IDENTIFIED BY VENDOR'S NAMES, ADDRESSES, AND PART NUMBERS HAVE BEEN TESTED AND APPROVED FOR USE IN THE END UNIT. A SUBSTITUTE ITEM SHALL NOT BE USED WITHOUT PRIOR TESTING AND APPROVAL BY AIRESEARCH.

10. IDENTIFY PACKAGING WITH AIRESEARCH NUMBER.

9. PARTS PROCURED BY VENDOR PART NUMBER SHALL BE PROCESSED IN ACCORDANCE WITH THIS AIRESEARCH SOURCE CONTROL DRAWING.

8. MACHINED SURFACES FLAT WITHIN .0005 PER INCH TO A MAX. OF .006 FOR ANY SURFACE.

7. MACHINED SURFACES NORMAL OR PARALLEL WITHIN .002 PER INCH TO A MAX. OF .012 FOR ANY SURFACE.

6. MACHINED DIAS. ON A COMMON CENTERLINE CONCENTRIC WITHIN .005 TIR, UNMACHINED DIAS. CONCENTRIC WITHIN .032 TIR.

5. DIMENSION LIMITS HELD AFTER PLATING.

4. MACHINED FILLET RADII .030 - .015

3. BREAK ALL CORNERS AND SHARP EDGES .015 MAX. NO HANGING BURRS ALLOWED.

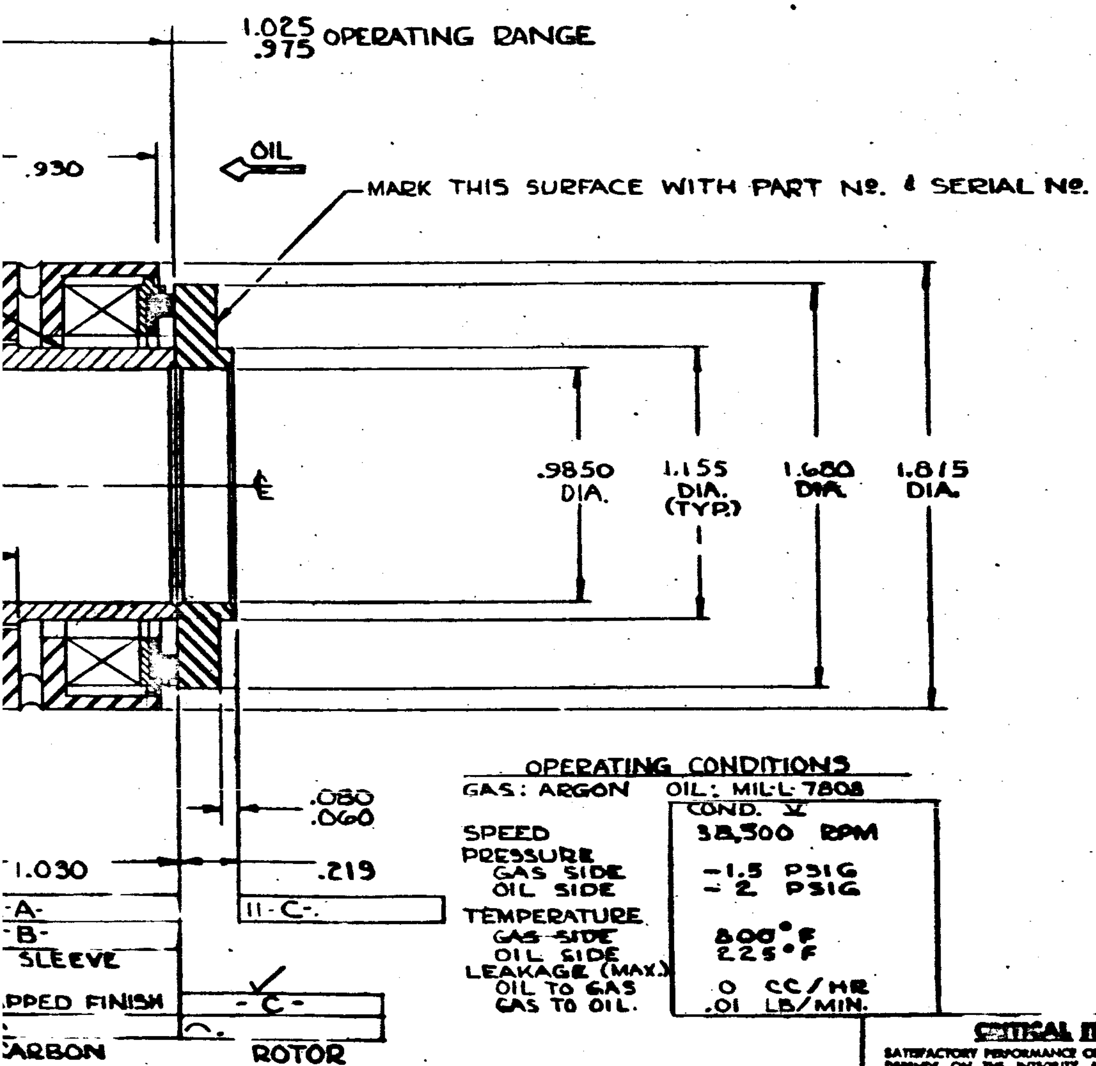
2. SURFACE ROUGHNESS PER MIL-STD-10.

. DIMENSIONS ARE IN INCHES.

[illegible]ESS OTHERWISE SPECIFIED.

1090

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



OPERATING CONDITIONS

GAS: ARGON   OIL: MIL-L-7808

	COND. V
SPEED	38,500 RPM
PRESSURE	
GAS SIDE	-1.5 PSIG
OIL SIDE	-2 PSIG
TEMPERATURE	
GAS SIDE	800°F
OIL SIDE	225°F
LEAKAGE (MAX.)	
OIL TO GAS	0 CC/HR
GAS TO OIL	.01 LB/MIN.

CRITICAL ITEM

SATISFACTORY PERFORMANCE OF THE END PRODUCT DEPENDS ON THE INTEGRITY AND RELIABILITY OF THIS SELECTED CRITICAL ITEM. PROCUREMENT OF THIS ITEM FROM THE GARRETT CORPORATION IS RECOMMENDED IN COMPLIANCE WITH ASPR 1.313.

Y. REQD.	ITEM NO.	PART NO.	SYM	DESCRIPTION	CODE IDENT	MATERIAL	SPECIFICATION	UNIT WT.

←ASSYS   LIST OF MATERIAL

NEXT ASSY.	USED ON
369753	369740
369753	369730
369753	369720

SIGNATURES	DATES
DFT. J. C. Jones	11/4/63
CHK. J. V. Matthews	11-5-63
MFG. ENG. RK	11-14-63
MAT. & PROCESS	
STRESS	
AERO.	
APP.	11-12-63
APP.	11-8-63
DESIGN ACTIVITY APP.	11-13-63
OTHER ACTIVITY APP.	

AiResearch Manufacturing Company of Arizona, Phoenix, Arizona

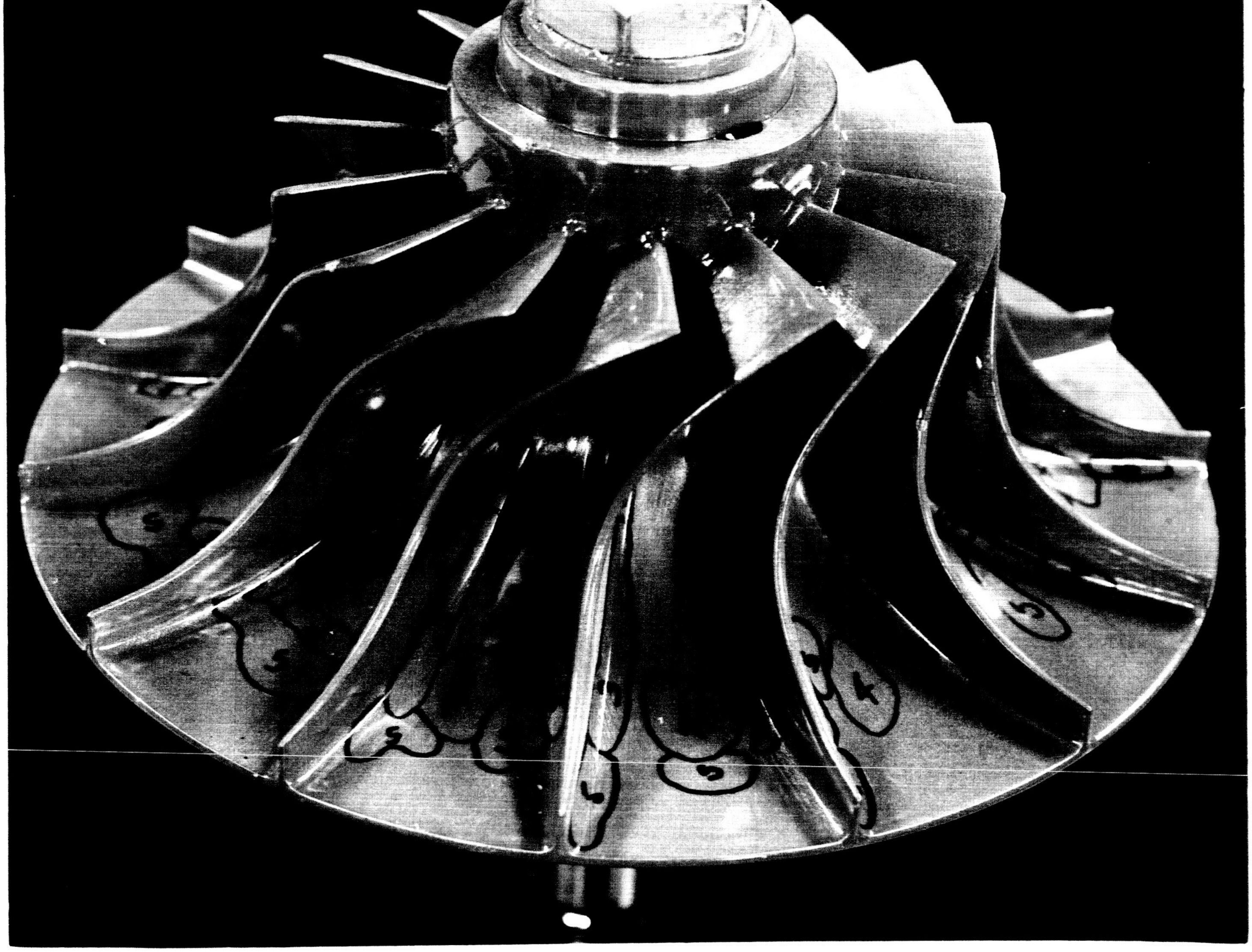
DWG. TITLE: SEAL SET, GAS-OIL, MATCHED

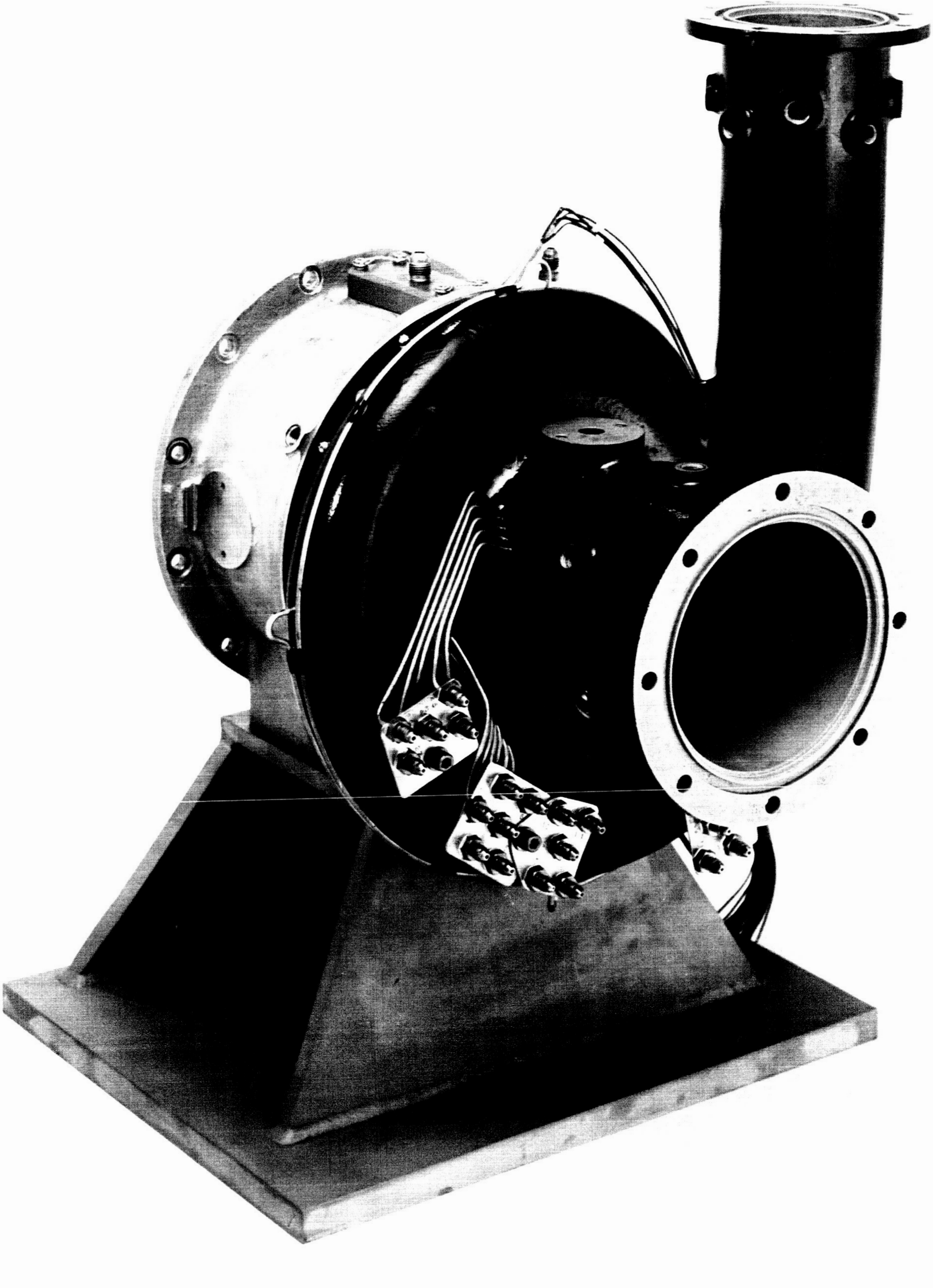
CODE IDENT NO. 99193 | SIZE C | DWG. NO. 358321

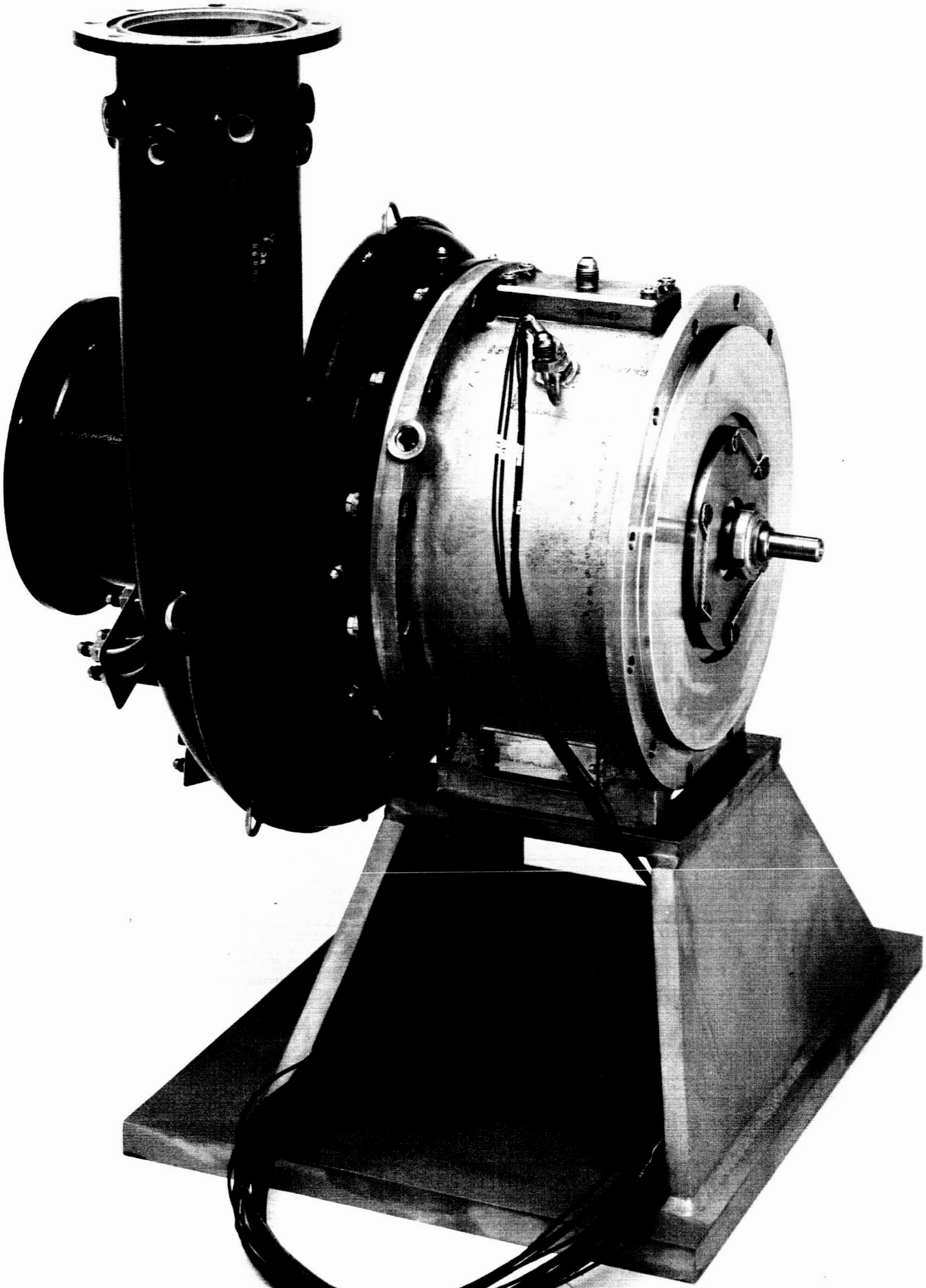
SCALE ½ 2 | WT. | SHEET 1 OF 1

DWG. NO. 358321

109 (2)

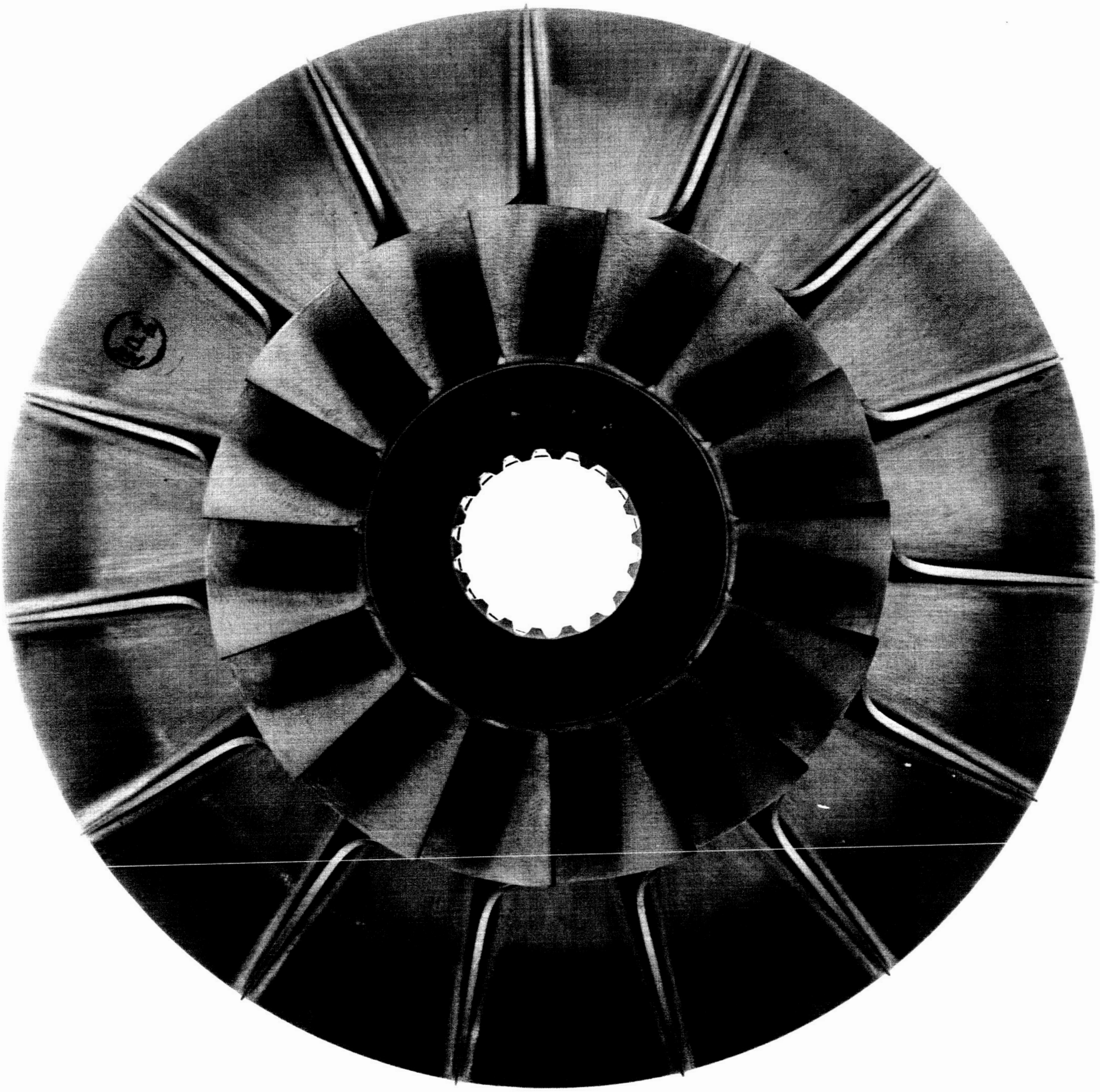


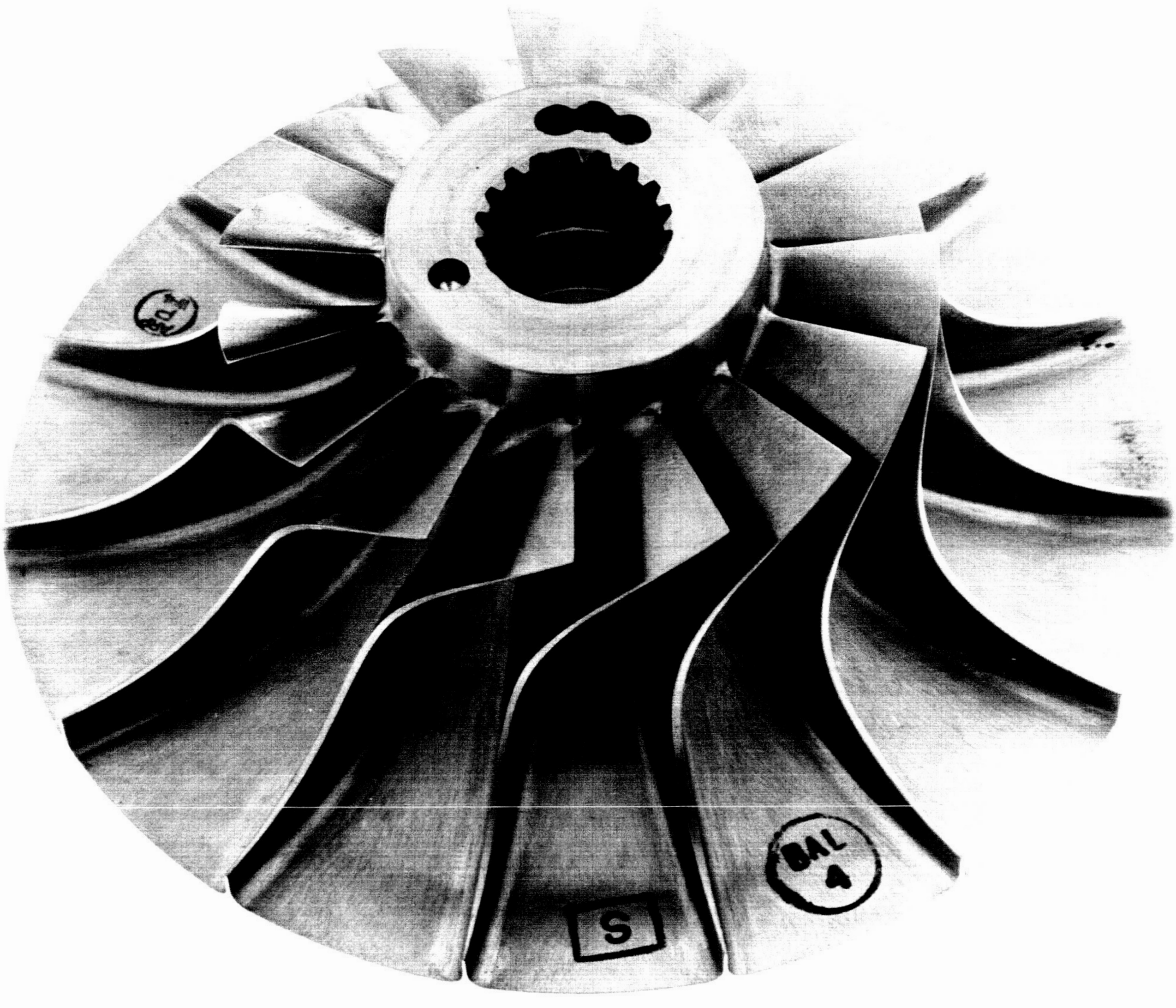




GARRETT

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

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